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Student Misconception In Chemistry: A Systematic Literature Review

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Abstract

This research is a systematic literature review study that aims to explore the evidence in publications that report on the types of misconceptions experienced by students in learning chemistry by providing types of students' chemical misconceptions based on levels and obtaining the correct formulation of misconceptions so that they can be used as a basis for overcoming them. The collected publications came from Scopus-indexed publications in journals, Conference Proceedings, Books, and Book Series from 2006 to 2021. Data analysis used was thematic analysis and data extraction and publication selection procedures using the PRISMA modification method, which consisted of four phases: identification, screening, eligibility, and inclusion. The linkages between all the literature with misconceptions were analyzed using VOSviewer software to visualize bibliometrics. There are four chemical materials with the most misconceptions experienced by students: chemical equilibrium with seven studies, covalent bonds with six studies, acid-base theory with five studies, and materials and their classifications with five studies. Countries actively researching misconceptions are the United States, Turkey, Taiwan, South Korea, Ireland, England, Colombia, Macedonia, India, Thailand, Slovakia, Indonesia, Spain, Malaysia, Finland, and Ukraine. The research findings provide an overview of chemical materials that students often experience misconceptions about and the types of misconceptions about these chemical materials.

Keywords: Chemistry, misconceptions, systematic literature review, VOSviewer.

Introduction

Berg & Clough (1991) suggest that constructivism can denote a trend within the philosophy of science, a class of learning theories, and many teaching strategies. Constructivist learning theory can explain that students have different conceptions even though they live in the same environment and follow the same lessons. The constructivist approach seeks to explain what is happening in students' heads. Students' pre-existing knowledge influences how students learn new scientific knowledge (Driver & Oldham, 1986). In studies, some students fail to achieve goals or objectives because of misconceptions that students have; this may be due to teaching methods or a lack of awareness of concept mastery (Bergquist & Heikkinen, 1990).

Misconceptions affect how students learn new scientific knowledge, play an important role in subsequent learning, and become a barrier to acquiring correct knowledge (Özmen, 2004). Identifying conceptual errors experienced by students is essential to improve the learning methods used(Üce & Ceyhan, 2019). Barke et al. (2009) stated that lessons should not only proceed from ignorance to other knowledge but must have knowledge that replaces existing misconceptions.

Misconceptions can occur in students because of a wrong understanding of learning obtained in high school (Nandiyanto et al., 2022). Misconceptions are situations where students' responses are not by scientific standards due to misinterpretation of concepts influenced by their previous conceptions (Tien & Osman, 2017). Misconceptions are stable cognitive structures that affect students' understanding of scientific concepts and are highly resistant to change (Taşlıdere, 2013). Yong & Kee (2017) state that parents, the environment, teachers, multimedia, and even students are responsible for fostering this misconception. Misinformation from textbooks and explanations is also accountable for misconceptions.

Concepts developed by students themselves often need to be more consistent with current scientific concepts (Barke et al., 2009). Conceptual confusion stems partly from over-generalizing sequential ways of thinking that are taken for what they are (Lowyck, 2014). According to Gurcay & Gulbas (2015), misconceptions resist change and hinder students' ability to understand scientific concepts and form new cognitive structures; thus, misunderstandings must be corrected. Replacing misconceptions with scientifically acceptable ideas is called conceptual change (Subari, 2017). To overcome misconceptions, Gooding & Metz (2011) suggest that teachers must first identify them, provide a forum

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for students to deal with them, and then help students reconstruct and internalize their knowledge based on scientific models. Misunderstandings can be corrected, but students must take the initiative to correct misconceptions. According to Üce & Ceyhan (2019), conceptual errors can be prevented by identifying conceptual knowledge that was previously inappropriate or wrong.

Wei et al. (2012) state that in learning, there are three main parts, namely plans, processes, and learning outcomes obtained after learning. Chemistry subjects have many chemical concepts that students must master, so teachers must be able to develop curiosity and curiosity in students to understand chemistry-related events. Elements of the chemical concept consisting of macroscopic, microscopic, and symbolic require an understanding of the concept that must be strengthened. Macroscopic consists of natural and visible phenomena, which may or may not be part of students' everyday experiences. Submicroscopic consists of the notion of the particulate level, which can describe the movement of electrons, molecules, and atoms. Symbolic consists of various pictorial representations, chemical symbols, equations, and algebraic and computational forms.

The primary purpose of chemistry lessons is to introduce students to nature or everyday phenomena and help them to understand what happens in nature (Barke et al., 2009). According to Shehu (2015), Chemistry is a subject full of interesting phenomena, exciting experiments, and valuable knowledge for understanding everyday life. But chemistry is a very complex subject, students not only need to understand the symbols, terms, and theories used in learning chemistry concepts, but they also need to change the language or learning materials used by the teacher to become meaningful representations.

Misconceptions are a barrier to students learning scientific knowledge (Behera, 2019). Misconceptions about a subject or subject matter can last long and are challenging to correct (Abenes & Caballes, 2020). There are various types and forms of matter in chemistry that experience misconceptions. According to Barke et al. (2009), researchers found that misconceptions in chemistry were caused by students and by inappropriate teaching methods and materials, which are called school-made misconceptions. Efforts and plans must be made to eliminate misconceptions so that participants can understand the concept of chemical matter correctly. According to Üce and Ceyhan (2019), removing misconceptions through direct teaching methods will be difficult because each learner constructs his knowledge, understanding, and concepts according to his abilities and experience, so it is necessary to identify misconceptions and then eliminate these misconceptions.

METHOD

Research Design

This study is a systematic review of literature reviews which claims to be the 'standard method' for literature review, i.e., replicable, transparent, objective, impartial, and rigorous, and thus superior to other approaches to conducting literature reviews (Boell & Kecmanovic, 2015). Systematic literature reviews provide a systematic and transparent means for collecting, synthesizing, and assessing study findings on a particular topic or question (Jesson et al., 2011). The literature collected comes from various sources that focus on the problem of misconceptions experienced by students, especially in the field of chemistry. The primary purpose of this research is to explore the evidence in publications that report on the types of misconceptions experienced by students in learning chemistry, to map the types of student chemistry misconceptions based on their level, and obtain the correct formulation of misconceptions so that they can be used as a basis for overcoming them.

Search Strategy

The collected publications come from Scopus-indexed publications in journals, Conference Proceedings, Books, and Book Series. The publication is limited only to the last 15 years, namely from 2006 to 2021; using the search keywords on Scopus is the misconception of chemistry education.

Data Analysis and Study Selection Criteria

Data analysis used in this research is the thematic analysis and data extraction (Khaizaar & Hidayat, 2022; Kusmaryono et al., 2022). Studies were selected if they met the following criteria: (1) were written in English, French, Spanish, Russian, Mandarin, and Arabic (2) discussed misconceptions in chemistry (3) explained in detail the types of chemical materials that experienced misconceptions. In the initial search, by considering the existing criteria obtained, the total number of publications is 348. The distribution of the number of articles by year is in Figure 1.

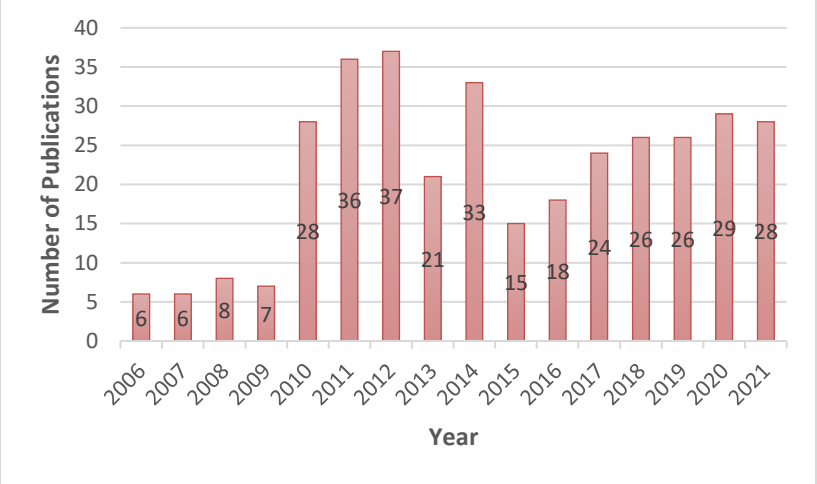

Figure 1: Distribution of the Number of Publications of Misconceptions in Chemistry by Year**.**

The 348 publications obtained were then determined according to research needs. The procedure for selecting publications, according to Figure 2, uses a modification of the PRISMA method, which consists of four phases: identification, screening, eligibility, and inclusion (Giovannoli et al., 2020).

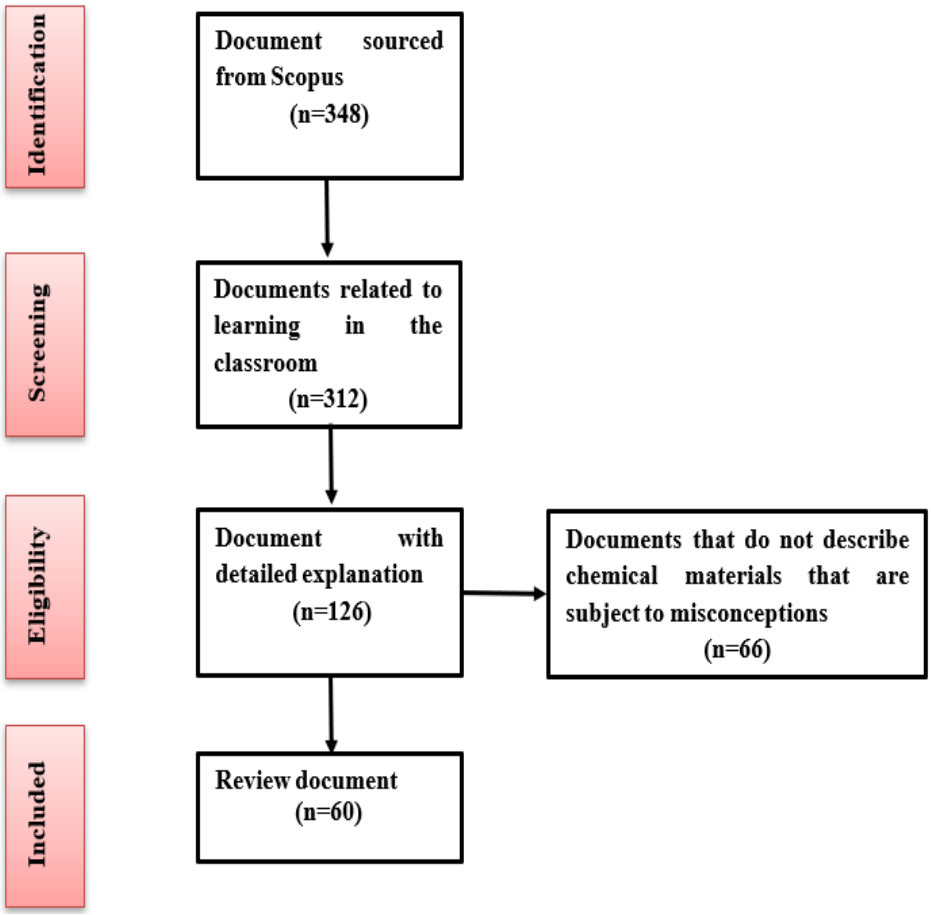

Figure 2: Publication Selection Procedure.

The linkages between all literature and misconceptions were analyzed using the VosViewer software to visualize bibliometric journals, Conference Proceedings, Books, and Book Series. The results of VosViewer are presented in Figure 3. The VOSviewer software aims to provide a graphical analysis of bibliometric data and visualization of research results (Kuzior & Sira, 2022).

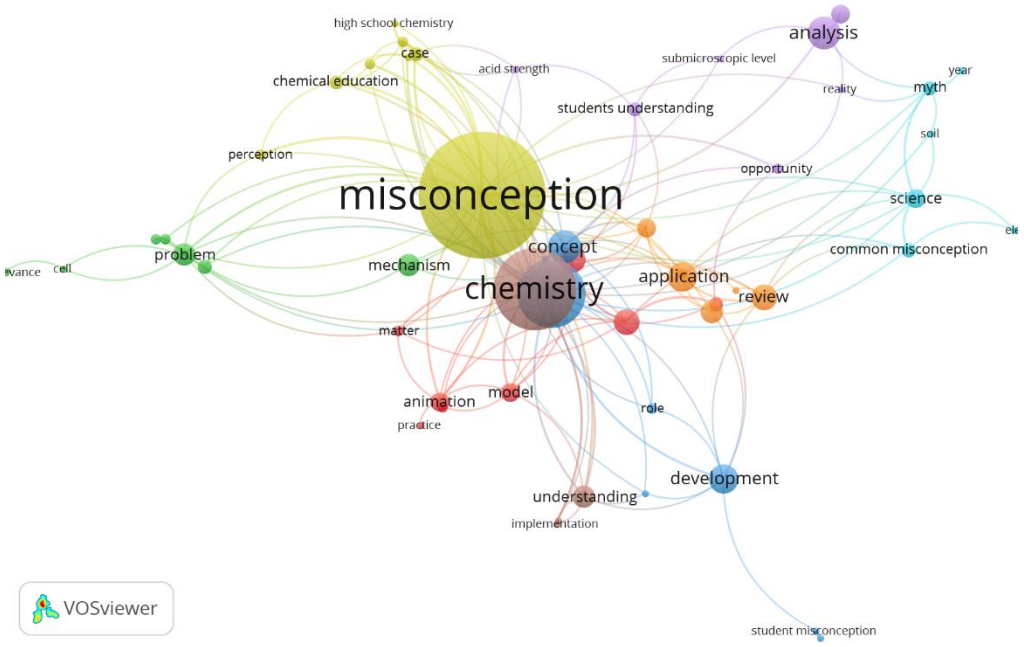

Figure 3: Publication Selection Procedure

Findings

The total number of articles collected from 2006 to 2021 was 348, and based on selecting the appropriate criteria, 60 articles were obtained, which show several misconceptions that occur in the field of chemistry, as shown in Table 1.

Table 1: Types of Misconceptions in Chemistry.

	Author and Year	Country	Identified Misconception	Types of Chemical Materials
1	(Yezierski & Birk, 2006)	United States of America	Misconceptions about particle properties	Material and classification
2	(Azizoglu et al., 2006)	Turkey	Misconceptions in Phase Equilibrium, changes in state from solid to gas and from gas to solid some students define change as evaporation, even though it is sublimation.	Chemical equilibrium
3	(Kerr & Walz, 2007)	United States of America	A misconception in environmental chemistry, many students continue to believe that ozone depletion is the cause of global warming.	Crude oil
4	(Sarikaya, 2007)	Turkey	One misconception that exists is that atomic numbers can be changed by rubbing objects together (If a proton transfer has occurred between things that are rubbed together, then there will be a transfer from one nucleus to another because protons cannot exist as independent particles in matter, it implies a change in atomic number)	Atomic theory
5	(Krause & Tasooji, 2007)	United States of America	Students need clarification about the definition of saturation and concepts related to solubility limits.	Solubility equilibrium
6	(Orgill & Sutherland, 2008)	United States of America	The misconception about buffer solutions is that they can consist of any acid and base in proportion, not necessarily a weak acid or weak base, and their conjugates.	Buffer solution

7	(Kahveci, 2009)	Turkey	The misconception that a substance is considered a compound if it is in the form of a molecule	Material and classification
8	(Cheung et al., 2009)	Taiwan	Of the 109 teachers participating in the test, only one understood that adding more gas CS_2 to an equilibrium system $CS_2(g) + 4H_2(g) \rightleftharpoons CH_4(g) + 2H_2S(g)$ at constant pressure and temperature could shift the equilibrium sideways reactants or products, depending on the amount of CS_2 in the initial equilibrium system. Most teachers rely on Le Châtelier's principle and thus make wrong predictions.	Chemical equilibrium
9	(Ünal et al., 2010)	Turkey	Misconceptions about covalent bonds, many students experience the misconception that covalent bonds are formed between metal and non-metal atoms.	Covalent bonds
10	(Pekmez, 2010)	Turkey	Misconceptions among students stating that adding reactants to an equilibrium reaction does not affect the concentration of the substance, and the increase in temperature does not affect the rate of the back reaction.	Chemical equilibrium
11	(Seo et al., 2010)	South Korea	The misconception about the definition of translational motion states that the length or angle of a molecular bond changes; in fact, that translational motion is all the points of the molecule moving with the same shape and speed.	Molecular shape
12	(Regan et al., 2011)	Ireland	Misconceptions about phase change, many students believe that when water evaporates, water molecules separate into hydrogen and oxygen atoms.	The essence of chemistry
13	(Taber, 2011)	UK	The misconception is that HCl is an ionic bond because the two atoms are non-metals, and the misconception is that MgCl2 is a covalent bond because magnesium is a metal and chlorine is a non-metal.	Covalent bonds
14	(Mayer, 2011)	United States of America	One of the most apparent misconceptions is that students believe gases weigh less than solids.	Atomic mass
15	(Tatar, 2011)	Turkey	Some participants thought that solid objects are heavier than liquids, they believed that the gas state of matter was the lightest of the others, and some participants felt that solids have volume while liquids and gases do not.	Atomic mass
16	(Duis, 2011)	Colombia	Misconceptions noted include: carbon atoms have more than or fewer than four bonds, and a hydrogen bond is any bond that involves hydrogen.	Intermolecular bonds
17	(Abell & DeBoer, 2011)	United States of America	Some students have the misconception that solid atoms don't move.	Atomic theory
18	(M. I. Stojanovska et al., 2012)	Macedonia	Some students stated that NaCl reacted with water, and NaOH and HCl were obtained. This student cannot differentiate between "react" and "dissolve."	Chemical formulas
19	(Mondal & Chakraborty, 2013)	India	Some misconceptions include assuming that atoms can be seen with a microscope, molecules expand when heated, ionic pairs such as Na^+ and Cl^- are molecules, and freezing and boiling are examples of chemical reactions.	Atomic theory and chemical bonds

20	(Yakmaci-Guzel, 2013)	Turkey	Some of the students' misconceptions are: The strength and concentration of an acid (or base) are the same things. Atoms and molecules have macroscopic properties; for example, they expand when a substance is heated. Chemical equilibrium is a static process; when chemical equilibrium is reached, the concentration of the products is equal to the concentration of the reactants.	Acid-base theory and chemical equilibrium
21	(Luxford & Bretz, 2014)	United States of America	Misconceptions about covalent bonds and ionic bonds, such as the misconception in brackets in one of the NaCl representation images, which states that brackets are concentrations	Covalent bonds
22	(Niroj & Srisawasdi, 2014)	Thailand	Some students experience the misconception that when gas reaches a high temperature of around 10,000 Celsius, it breaks down into hydrogen and oxygen molecules, and some students say it breaks down into H^+ and OH^- .	The essence of chemistry
23	(Maass & Krause, 2014)	United States of America	The most common misconception about solutions and solubility for liquid and solid phases is that supersaturated solutions contain liquid and solid phases, not supersaturated solutions, which include excess solute in concentrations above equilibrium.	Solubility and solubility product
24	(K. C. Smith & Villarreal, 2015)	United States of America	Some students needed clarification about the dissolving process.	Material and classification
25	(Çam et al., 2015)	Turkey	Students need clarification about the critical concept of reaction rate and assume that the rate of reaction is equal to the multiplication of the concentration of the reactants.	Reaction rate
26	(Tümay, 2016a)	Turkey	The majority of students need to conceptualize acid strength as a property that arises from interactions among various factors. They generally focus on a single element to predict and explain acid strength, and their incorrect response stems from their failure to recognize and consider all the factors that affect acid strength.	Acid base theory
27	(Vrabec & Prokša, 2016)	Slovakia	One of the misconceptions many students have is the idea of shared electron pairs between sodium and chlorine atoms in sodium chloride; they believe that the bonds in sodium chloride are covalent.	Covalent bonds
28	(Sunyono et al., 2016)	Indonesia	Students argue that any p orbital can have any value of the magnetic quantum number.	Atomic structure
29	(Tümay, 2016b)	Turkey	Students' conceptualization of the "octet rule" as a precise rule rather than a chemical heuristic leads to many learning difficulties and misunderstandings about chemical bonds.	Chemical bond
30	(Erman, 2017)	Indonesia	The misconception about covalent bonds is that every atom in a stable molecule obeys the octet rule, especially the central atom.	Covalent bonds
31	(Sopandi et al., 2017)	Indonesia	Most students still need to understand the matter and its changes thoroughly.	Material and classification
32	(Nelson et al., 2017)	United States of America	Misconceptions in students stating that the movement of electrons is not random	Atomic theory

33	(Cañada et al., 2017)	Spain	Students experience difficulties concerning the difference between homogeneous and heterogeneous mixtures.	Material and classification
34	(M. Stojanovska & Petruševski, 2017)	Macedonia	Some students experience a misconception that sodium chloride solution is an alkali and a mistake in naming the compound.	Nomenclature of compounds
35	(Walanda et al., 2017)	Indonesia	Some students need clarification about sequencing the stages of electrochemical cells, and there are misconceptions from students about determining the locations of salt bridges.	Electrochemistry
36	(Widarti, Retnosari, et al., 2017)	Indonesia	Some need clarification about resonance theory; many think that resonance structures are in balance with each other because they see the use of arrows.	Chemical Bonds
37	(Widarti, Permanasari, et al., 2017)	Indonesia	Most misconceptions occur in the answers to questions: "what should be done if the Erlenmeyer flask provided has been rinsed but not yet dried and will be used immediately for titration of HCl with NaOH solution" students explain that Erlenmeyer must be rinsed with HCl solution instead of aquadest.	Titration
38	(Hwa & Karpudewan, 2017)	Malaysia	Most students think that a mixture of acetic acid and sodium bicarbonate will produce a neutral substance because acetic acid will neutralize the essential nature of sodium bicarbonate.	Hydrolysis of Salt
39	(Mubarokah et al., 2018)	Indonesia	Students choose CH3COOH as a base solution because it contains OH- ions. This means some students need clarification about the concept of acids and bases.	Acid base theory
40	(Kusumaningrum et al., 2018)	Indonesia	Students have misconceptions about the question, "Does the solution's volume affect the buffer solution's capacity?" The buffer solution capacity is also significant. Some students think that it doesn't matter because the concentration of a weak acid/base and its conjugation are used in the Henderson-Hasselbalch equation. So, the capacity of the buffer solution is only affected by concentration.	Buffer solution
41	(Surif et al., 2018)	Malaysia	Students experience the misconception that chemical reactions always occur continuously until all the reactants are used up. In reality, a chemical reaction will reach equilibrium before all of the reactants are used up in the reaction. This concept has been proven in equilibrium balances and Le Chatelier's Principle.	Chemical equilibrium
42	(Liliasari et al., 2018)	Indonesia	Students experience misconceptions explaining the phenomenon of calcium carbonate deposition on tap water heating.	Solubility and solubility product
43	(Lamichhane et al., 2018)	United States of America	Some students need clarification on the constant rate concept and help to understand the relationship between rate constant and reaction rate.	Reaction rate
44	(Siswaningsih et al., 2019)	Indonesia	The misconception that most students experience is the concept of dynamic equilibrium, which states that in an equilibrium state, the concentrations of reactants and products are the same because, in an equilibrium state, the concentrations of reactants and effects are the same.	Chemical equilibrium

45	(Talib et al., 2018)	Malaysia	High school students need help understanding acid-base chemistry because they have difficulty understanding acids and bases as ions.	Acid base theory
46	(Lawrie et al., 2019)	Taiwan	Students have poor preparation in periodic properties, equilibria, solubility, and energy transfer in chemical processes.	Periodic system of elements
47	(Prodjosantoso et al., 2019)	Indonesia	Misconceptions occur due to students needing to understand the ionic bonds formed by cations and anions. Meanwhile, in the concept of forming ionic bonds, there are exceptions where the interactions between cations and anions do not always form ionic bonds, such as in HCl compounds. The interaction between H^+ ions and Cl^- ions do not produce ionic bonds but covalent ones.	Ionic Bonds
48	(Härmälä-Braskén et al., 2020)	Finland	In the matter of changing the phase of water, it shows that some have misconceptions about the phase change of boiling water by saying that evaporation is a chemical reaction when water evaporates and turns into the air. Water separates into H_2 and O_2 when it disappears.	The essence of chemistry
49	(Llanos et al., 2021)	Spain	Based on the results of the evaporation exercise, students still need to clearly understand the primary variable's effect on the solution's boiling point.	Colligative properties of solutions
50	(Nasrudin & Azizah, 2020)	Indonesia	The misconception is the need for more ability of students to describe a submicroscopic representation of a phenomenon to distinguish the concepts of temperature and heat.	Thermochemistry
51	(Murniningsih et al., 2020)	Indonesia	Students experience misconceptions about redox because they need to understand the problems of reduction and oxidation, and students are still not precise in determining reactions that take place spontaneously.	Reduction oxidation reactions
52	(Jusniar et al., 2021)	Indonesia	Misconceptions about reaction rates are the assumption that activation energy is the amount of energy released during a reaction and that catalysts do not affect the reaction mechanism.	Reaction rate
53	(Mubarak & Yahdi, 2020)	Indonesia	Students misconceptions are caused by confusion in understanding the concepts of hard and soft acids and bases.	Acid base theory
54	(Widarti et al., 2021)	Indonesia	Students' misconceptions assume that before carrying out the Erlenmeyer titration that will be used, it must be washed with HCl and dried with tissue paper, and some are directly utilized; in the stoichiometric aspect, students write the wrong reaction equation.	Titration
55	(Morales & Tuzón, 2020)	Spain	There needs to be clarity caused by the terms 'radiation' and 'radioactive material.'	Elemental Chemistry
56	(Derkach, 2021)	Ukraine	Students experience misconceptions about the concept of polarity and failure to distinguish between covalent, polar, and nonpolar bonds; confused with the concepts (neutron, proton, electron, and mass number); lack of understanding of the change in atomic radius when electrons combine.	Covalent bonds

57	(Rusmini et al., 2021)	Indonesia	Students need help in abstracting the concept of acids and bases correctly.	Acid base theory
58	(Kiray & Simsek, 2020)	Taiwan	The misconception is that the volume of liquid mixed in the dissolved liquid does not affect the density of the mixture.	The essence of chemistry
59	(Andriani et al., 2021)	Indonesia	The misconception that the concentrations of products and reactants are equal at equilibrium and the belief that no reactions occur at equilibrium and that equilibrium is static.	Chemical equilibrium
60	(Harza et al., 2021)	Indonesia	In the concept of chemical equilibrium, many students still think that in an equilibrium system, the rate of the forward reaction differs from the rate of the reverse reaction.	Chemical equilibrium

The distribution of the 60 reviewed articles by country of research on misconceptions in chemistry is shown in Figure 4.

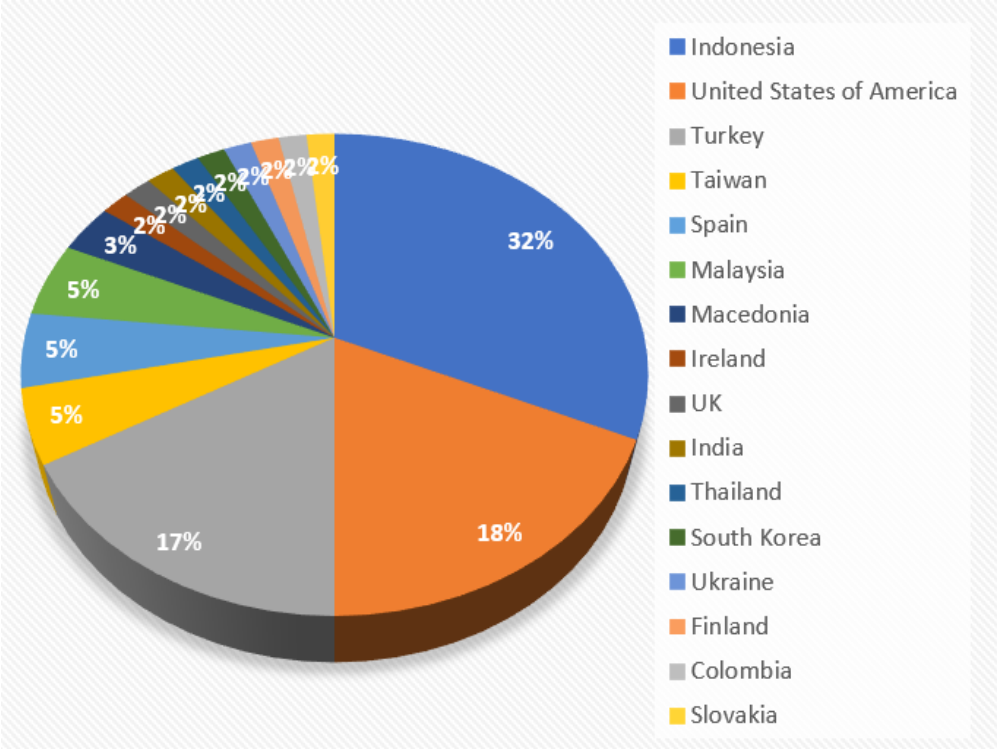

Figure 4: Distribution of Publications of Misconceptions in Chemistry by Country.

Discussion

Misconceptions refer to students' wrong knowledge or misunderstandings and confusion when students construct specific knowledge (Soeharto & Csapó, 2022). Misconceptions in the field of chemistry always occur from year to year. From 2006 to 2021, 60 studies specifically obtained data about student misconceptions. Research on this misconception was conducted in various qualitative and quantitative ways using various methods. Research trends on misconceptions in chemistry are always prominent every year; this is due to the enormous impact of misconceptions on students' knowledge. Misconceptions are a barrier to students learning scientific knowledge (Behera, 2019).

Smith (2022) states that chemistry is a complex and challenging subject for students; they sometimes already have previous concepts about the material being studied, which may or may not be in line with supposed scientific ideas. Students in various studies need clarification. Based on the material with the most misconceptions is presented in Figure 5.

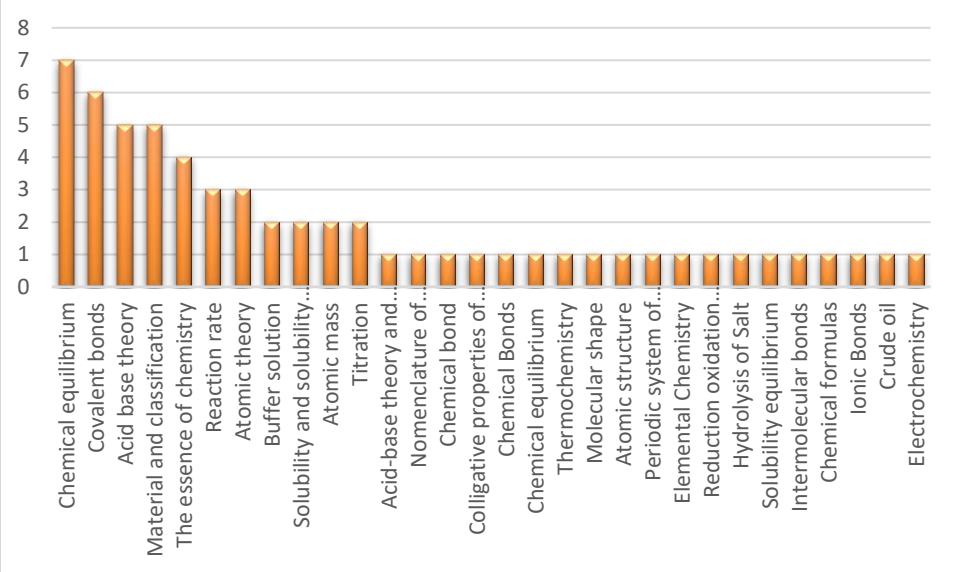

Figure 5: Misconception Material in Chemistry.

Figure 5 shows five chemical materials with the most misconceptions experienced by students. The first material is chemical equilibrium. A good understanding of chemical equilibrium is needed to understand other chemical concepts, such as acid-base, oxidation-reduction reactions, and solubility (Andriani et al., 2021). There are many misconceptions about chemical equilibrium, such as misconceptions about the definition of evaporation, misconceptions that the addition of reactants into an equilibrium reaction does not affect the concentration of substances, and misconceptions that the rate of the forward reaction is not the same as the rate of the reverse reaction can have an impact on other chemicals related to chemical equilibrium (Azizoglu et al., 2006; Harza et al., 2021; Pekmez, 2010). The second material that needs to be understood is covalent bonds. Covalent bonds are one of the main concepts in chemistry. Teachers can use concrete, analogical, theoretical, and simulation learning models to prevent student misconceptions, such as making concepts more concrete for students. The emphasis on the macroscopic matter to sub-microscopic matter can solve the misconception about covalent bonds (Ünal, 2010). The third material that has many misconceptions is the acid-base theory. To prevent misconceptions about acid-base theory, teachers must know the nature of chemical science, and it is necessary to reconceptualize chemistry learning by prioritizing chemical epistemology (Kousathana, 2005). The fourth material is material and classification. To prevent material and classification misconceptions, what is needed is that the teacher must deepen the learning material rather than focus on learning methods (Ayyıldız et al., 2022). The fifth material is the essence of chemistry. To overcome misconceptions about the essence of chemistry, teachers can use active learning, cooperative learning, and socio-scientific issues learning. Active learning, cooperative learning, and socio-scientific issues learning are used because they are consistent with socio-cultural constructivism (Suparman et al., 2022; Tsaparlis & Papaphotis, 2009).

An analysis of 60 studies showed that the chemistry material taught in the first semester of high school was the chemical material that had the most misconceptions. The material for the first semester of chemistry in high school that has many misconceptions is the material for chemical equilibrium. This is to research conducted by Rahmawati et al. (2022), which stated that based on an analysis of misconceptions using the Rasch measurement model and the percentage of misconceptions, students experienced many misconceptions about chemical equilibrium material. Misconceptions in students in this early semester need to be identified, and solutions are given so that they do not continue to become structured misunderstandings. According to Bayrak (2013), abstract and difficult-to-understand concepts are sometimes structured in students' minds in a way that is different from what is targeted. For students to understand concepts correctly, teachers who explain concepts in class must configure the images in their minds so that studies are required to determine misconceptions (Dogan & Demirci, 2011). Misconceptions resist change and hinder students' ability to understand scientific concepts and form new cognitive structures; therefore, misconceptions about ideas must be corrected (Gurcay & Gulbas, 2015).

Various studies conducted on misconceptions from 2006 to 2021 provide knowledge to teachers about the types of misconceptions and where misconceptions are experienced by students in the field of chemistry so that appropriate solutions can be provided. This is what was conveyed by Nandiyanto et al. (2022) that identifying prior knowledge at the beginning of learning is essential for detecting misconceptions in students. If students have misconceptions, teaching must be planned in such a way as to eliminate these misconceptions.

Most of the research findings regarding misconceptions were carried out in Indonesia, the United States of America, and Turkey. These findings prove that misconceptions are not only interesting for countries in the Asian continent, but in the Americas; they are also exciting and essential to study. The research results obtained that more misconceptions occur among students. This is to the findings of Vladusic et al. (2022) that the highest percentage of misconceptions happens among students, students, and teachers. Weaknesses in students'

thinking can develop into misconceptions, sometimes directly caused by textbooks or teachers.

Conclusion

The results of the research show various studies related to misconceptions in chemistry. Based on the results of the article review from 2006 to 2021, 60 articles were obtained that were appropriate and examined explicitly the parts of the material that students had misconceptions about. Various countries are actively researching misconceptions, such as the United States of America, Turkey, Taiwan, South Korea, Ireland, the UK, Colombia, Macedonia, India, Thailand, Slovakia, Indonesia, Spain, Malaysia, Finland, and Ukraine. The research findings provide an overview of chemical materials that students often experience misconceptions about and the types of misconceptions about the chemical material. Teachers and other researchers can use this research to identify misconceptions in students and find solutions to these misconceptions.

Suggestion

Future research can use the research results as input in determining solutions to the misconception problems experienced by students, especially in the field of chemistry. Future research can also use the results of this study to create appropriate diagnostic test instruments to identify types of chemical misconceptions by modifying the types of chemical materials that often experience misconceptions based on students' character and habits in learning. In addition, teachers can use the results of this study as a reference in determining the types of misconceptions experienced by their students.

Limitation

This research provides transparent information about the types of misconceptions students learning chemistry often experience, but this research still has limitations in the articles analyzed only sourced from Scopus. This research needs to be expanded from journals, Conference Proceedings, Books, and Book Series indexed by the Web of Science and Google Scholar so that the scope of material is broader and the information obtained is also increased.

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