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Exploring Science Teacher Prospective Misconception in Hydrocarbon: a Diagnostic Three Tiers Test

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Abstract

Chemistry learning is considered a difficult and complex subject for some students and prospective science teachers. For this reason, it is necessary to know the understanding related to chemistry learning, especially on hydrocarbon materials so as not to cause misconceptions. The aim of this research is to identify organic chemistry misconceptions among prospective science teacher students regarding hydrocarbon material, namely the characteristics of hydrocarbons and isomers of chemical compounds. This research approach was qualitative using descriptive analyze combined with systematic literarature review and bibliometric. Determining misconceptions using a modified three tiers diagnostic test. The research subjects were 12 students and the questions tested were 10 essay questions. The results of the research showed that high misconceptions (81.2%) regarding naming, chemical reactions, isomers, and chirality, highlighting the prevalence of misconceptions in basic concepts. This research emphasizes the importance of good concept understanding to prevent misconceptions among prospective science teachers.

How to Cite

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INTRODUCTION

A complex phenomenon that the main purpose of science learning is to teach the understanding of concepts. A good understanding of concepts supports students in processing information effectively and efficiently (Widiyatmoko & Shimizu, 2018). Conceptual understanding is one of the indicators that determines the success of organic chemistry learning outcomes (Rico & Fitriza, 2021).

Chemistry is a branch of science that deals with the identification and transformation of the substances that make up matter, while organic chemistry focuses on carbon-based compounds. Organic Chemistry involves the study of the structure, reactions, and properties of organic compounds. Organic compounds in the human body include proteins, carbohydrates, and other macromolecules that are important in supporting life (Salame et al., 2019).

Most students consider that chemistry to be very complicated. As a result, most students give up on the lesson (Kausar et al., 2022). They have not yet gained a change in seeing molecules, atomic particles or subatoms with any advanced instruments. We know the existence of these particles through the interaction of the particles through advanced analysis; Therefore, it is equally difficult for teachers to set up a teaching environment for students to understand the submicroscopic properties of chemistry that are still not visible (Tüzün et al., 2022).

Organic chemistry, as experienced by most students in the classroom and used in most laboratories, is more akin to an algorithm than a coherent conceptual framework. This limitation is exacerbated by the relatively simple understanding of the nature of science possessed by most students (Healy, 2019). Organics offer great context for many chemistry topics in general. Topics such as kinetics, equilibrium, hybridization, etc., can be introduced (Risqi et al., 2021).

Organic chemistry is one of the essence courses in the Science Education curriculum that students must master before studying Biochemistry courses. However, Organic Chemistry is considered a difficult subject in the branch of chemistry, this causes students to be hindered from understanding the next material (Treagust et al., 2018). The results of the initial observation of the ability to test organic chemistry for the basic concepts of Nomenclature and Function Clusters obtained an average score of 68.70. The results of the unstructured interview also indicate that students still have difficulties in understanding the rules of compound nomenclature.

The results of the preliminary study show that there are still many students who have difficulty learning the concepts of organic chemistry (Pratama et al., 2023). After all, concepts are fundamental in understanding a topic of science. Learning the concepts of organic chemistry before practicing them is important because it provides a fundamental understanding of the underlying principles and mechanisms, allowing for more meaningful engagement with direct activities, better interpretation of results, and a deeper understanding of the scientific phenomena being investigated; Basically, it provides context and direction to practice, resulting in more effective learning. Treating organic chemistry at the undergraduate level is as important as applied science or technology (Healy, 2019).

In organic chemistry learning according to (Anim-Eduful & Adu-Gyamfi, 2022), problems were found that ultimately resulted in students having the opportunity to develop thinking skills in conceptual alternatives. Students are forced to memorize formulas that are not a good method in any meaningful learning. The results of the previous test showed that students experienced misconceptions in answering the reasons for the questions. One method to recognize the extent to which students have misconceptions of concepts can be using diagnostic tests. According to (Siswaningsih et al., 2019), The three-level multiple choice diagnostic test can be used to determine students' misconceptions about certain topics. Where it consists of three levels. The first level consists of conceptual knowledge. The questions used are in the form of a supply response (a form of description or short answer) so that they are able to capture complete information. The second level is the reason for choosing the answer (evidence). While the third level is students' confidence in choosing answers.

The urgency of the research were: 1) Understanding misconception. The research emphasizes the importance of identifying and comprehending misconceptions in organic chemistry, especially among future science teachers. These misconceptions can obstruct effective teaching and learning processes, making it essential to address them to improve educational outcomes; 2) Improving chemistry education. Given that chemistry is often perceived as a difficult subject, this research is timely in seeking to enhance educational strategies and outcomes for students in science education; 3) Impact on future educators. As the study focuses on prospective science teachers, the findings can directly influence how future

educators approach teaching organic chemistry, thereby impacting generations of students.

This article research gap were insufficient understanding of hydrocarbon concepts, while previous studies have indicated that students struggle with fundamental concepts in organic chemistry, but there is limited research focusing on the specific areas of hydrocarbons and their properties. The novelty of this research were focus on prospective science teacher and comprehensive analysis of misconceptions.

METHOD

The approach of this research is qualitative (see figure 1 below). Qualitative research is a type of research that aims to understand the phenomena of the research subject, such as behavior, perception, motivation, action, and others, thoroughly (wholely) and by describing them in language and words, in a specific natural context, and by utilizing various natural methods. In line with (Creswell & Angeles, 2011) qualitative research is research in which researches study problems that have the goal of exploring phenomena. Qualitative research is research in which researchers study problems that have the goal of exploring phenomena.

This study seeks to identify misconceptions of students in organic chemistry courses. The subject of the study is 12 students who are prospective science teachers in the Class of 2023. This research was conducted in the odd semester of the 2024/2025 Academic Year. Data collection techniques use diagnostic and interview instruments, as well as documentation.

The research procedure includes three stages, namely the preparation, implementation, and final stages. In the preparation stage: 1) Literature study in the form of understanding the concept of hydrocarbon materials and FGD related to diagnostic tests; 2) making question grids; 3) the creation of a three-tier diagnostic test instrument, where the second tier uses the reason for the essay to find out the extent of the student's understanding of the concept; 4) expert validation. The test instrument grid developed is a modified three-tier diagnostic test instrument consisting of 6 indicators, namely: 1) identification of functional clusters; 2) the boiling point of hydrocarbons; 3) general reactions of hydrocarbons; 4) hydrocarbon derivative nomenclature; 5) identification of structural isomers; 6) stereochemistry according to the research grid showed in Figure 1.

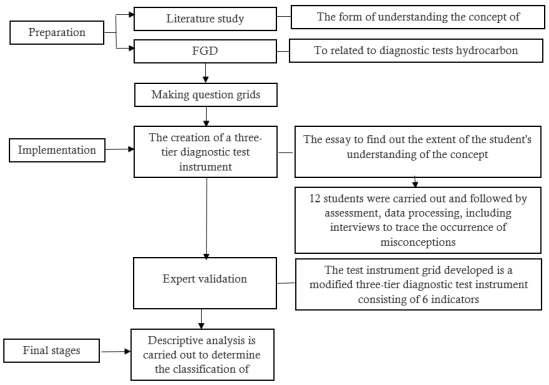


Figure 1. Data Collection Techniques

To comprehensively measure the level of understanding of the research object, it is done by making a list of questions that are accumulated into a descriptive measure (Table 1).

Table 1. Modified three-tier diagnostic question grid

Course Learning Outcomes	Sub Course Learning Outcomes	Number of Questions
Able to identify the characteristics of hydrocarbon compounds	Identification of functional groups of organic compounds	1
	Analyzing the boiling point of compounds resulting from petroleum fracturing	2
	Distinguishing common reactions in hydrocarbon compounds	5,10
	Analyzing the nomenclature of hydrocarbon compounds and their derivatives	3,4
Isomers and stereochemicals	Distinguishing isomer types in structural isomers	6,7
	Identifying the chiral center of the compound	8
	Understanding the concept of stereoisomers	9

Based on the results of validation carried out by 3 expert validators of 15 questions, only 12 questions were acceptable. However, to be able to explore misconceptions, 10 questions were used. As for the expert revision results, the results obtained are according to Table 2 below.

Table 2. Expert validation results

Rated Criteria	Aspect item number	Aspects that need to be revised	Items that need to be corrected
Material	3	Not all distractors work	No. 10
	4	The time provided is adjusted to the form of the question	No. 7
Construction	7	The length of the question formulations is not the same, they need to be sorted from shortest to longest	No. 5
Language	9	The language used is difficult to understand	No. 3

At the implementation stage, 12 students were carried out and followed by assessment and data processing. In the final stage, a descriptive analysis is carried out to determine the classification of misconceptions, including interviews to trace the occurrence of misconceptions. The research data taken although only a little, but strengthened with a depth interviews about misconceptions that occur. The type of data of this study is a modified three-tier diagnostic test. This three-tier instrument is a modification of the three-tier multiple choice diagnostic test. Tier 1 is in the form of understanding the concept of Right/False. Tier 2 is in the form of proof (reason) of the answer in the form of an essay, and Tier 3 is in the form of reasoning (Kustiarini et al., 2019).

The percentage of misconception level sought in the second tier is to find evidence using the following formula:

$P = (f/N) \times 100\%$

Description:

P = Percentage
F = Frequency searched
N = The number of individuals

Table 3. Percentage of misconception rate

Percentage	Categories
0-30%	Low
31-60%	Middle
61-100%	High

Table 4 presents the measurement value of the assessment results of a number of questions and the results of the research object interviews and then compared with the validation results of the validation experts to then be descriptive as an indicator of misconception (Arslan et al., 2012).

Table 4. Grouping of Student Understanding Categories

Student Response			Categories	Code
(First tier) Answer	(Second tier) Reasons	(Third tier) Belief		
True	True	Sure	Know the Concept	KC
True	True	Not sure	Don't Know the Concept (Luccy Guess)	DKC
True	Wrong	Not sure	Don't Know the Concept	DKC
Wrong	True	Not sure	Don't Know the Concept	DKC
Wrong	Wrong	Not sure	Don't Know the Concept	DKC
True	Wrong	Sure	Misconceptions 1 (False Positive)	MC 1
Wrong	True	Sure	Misconceptions 1 (False Negative)	MC 2
Wrong	Wrong	Sure	Misconceptions 3	MC 3

The decision on the category of misconception understanding for the next is shown based on Table 4 above. The methods in this study are combined with systematic literature review and bibliometrics visualized with VOS to obtain research gaps and findings and recommendations for future research relevant to this article.

RESULT AND DISCUSSION

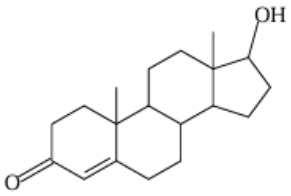
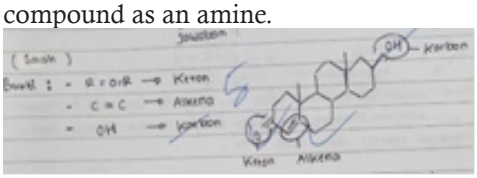
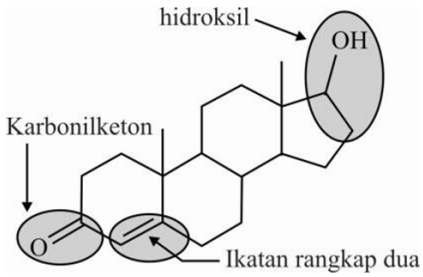
Two-tier, three-tier, and four-tier diagnostic tests are suggested to find misconception in chemistry (Rosida et al., 2022). The instrument tested in this study is a modified three-tier diagnostic instrument. This instrument has been expertly validated by 3 experts. The aim of expert validation is so that the instrument can be accepted based on theoretical considerations and their experience as experts (Suryanda et al., 2019). The selection of three tiers is because it is considered more valid and reliable for detecting misconceptions than two tiers (Mubarak & Yahdi, 2020); (Prodjosantoso et al., 2019). In addition, what is meant by the modified part of this three tier is to use description questions rather than multiple choice. Descriptive diagnostic questions provide more complex answers than multiple choice-based instrument types (Rokhim et al., 2023). The results of the modified three-tier diagnostic test instrument are correlated with table 3 and table 4 shown in the following Table 5.

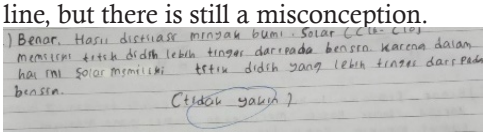
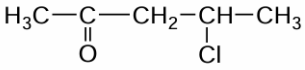
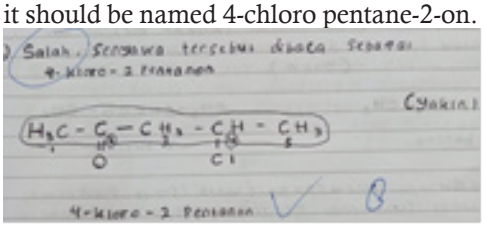
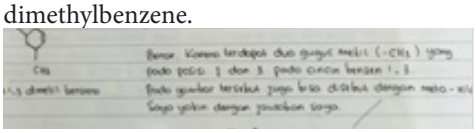
Table 5. Results of misconception percentage

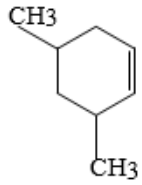
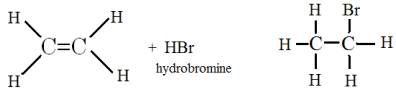
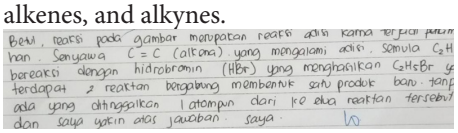
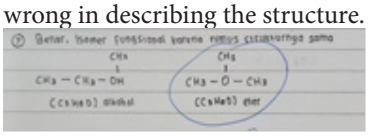
No. Of Questions	(%) Categories of misconceptions			Misconception rate
	KC	DKC	MC	Tier 2
1	66.7	25	8.33	Low
2	75	16.7	8.33	Low
3	16.7	-	83.3	High
4	-	-	100	High
5	100	-	-	Low
6	33.3	-	58.3	High
7	66.7	-	33.3	Middle
8	8.33	8.33	83.3	High
9	66.7	16.7	16.7	Low
10	-	16.7	83.3	High

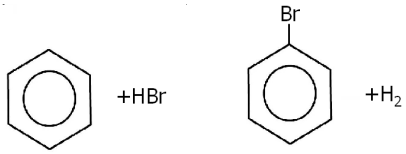
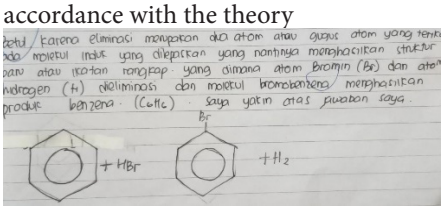
Based on table 5, it is obtained that the low level of misconception is in numbers 1,2,5, and 9. While the medium level of misconception is in number 7, and the high level of misconception is in numbers 3,4,6,8, and 10. The summary of misconceptions from all items can be seen in the following Table 6.

Table 6. Summary of misconceptions on instrument items

No Questions	Concept	Misconception
1	Identification of functional groups of organic compounds. In the following compounds, there are functional groups of organic compounds, namely amines, hydroxyls, and ketones. a) testoteron (hormon pria) 	There is still a misconception in determining the functional group attached to a compound. Some consider that the OH group is a carbon compound, a double compound as an amine.  In the picture next to the functional groups involved are ketones, alkenes, and hydroxyls.  To explore further about the conceptual difficulties in the identification of functional clusters, further interview techniques are needed (Adu-Gyamfi & Anim-Eduful, 2022)

2	Boiling point analysis of alkane compounds The distillation of petroleum, diesel (C16-C18) has a higher boiling point than gasoline (C6-C12)	The majority of students know that the boiling point of diesel is higher than gasoline, but there is still a misconception.  There are still those who answer that the hydrocarbon compounds with the highest boiling point are the compounds with the most number of carbon atoms and the most branches. This is because students believe that the more branches a compound has, the harder it is to untie the bond, which requires more energy to break the bond. It should be due to the van der waals tensile force between longer and straighter molecules, so that compounds with long and straight chains have a higher boiling point to choose their relationship (Vellayati et al., 2020).
3	Nomenclature of ketone compounds The compound below reads as:  2- cloro – 4 pentanon	They still fail to understand the concept of compound nomenclature rules, including the priority of functional groups. Most of them cannot distinguish between the main chain and the subsituent chain. In this case the main chain is alkanone, and the subsituent is chloro, so the numbering starts from the carboxyl. The compound next to it should be named 4-chloro pentane-2-on.  This is in line with (Ubanwa, 2016) that twenty percent of students face difficulties in studying hydrocarbon materials, especially in compiling the structure of compounds and giving IUPAC naming. This difficulty is also supported by the lack of understanding of students in the basic concepts of organic chemistry (Akkuzu Güven & Uyulgan, 2016).
4	Nomenclature of cycloalkene compounds. The compound below is named meta-1,3 dimethylbenzene	All students answered Correct and Confident that the compound on the side is meta-1,3 dimethylbenzene.  Many students are still unable to give numbering priority to the double bond function group.

		The number 1 should be given in the first copy. Meta naming rules, para can only be in the benzene structure. While the compound on the side is not benzene but cycloalkene. The proper naming should be 3,5-dimethylcyclohexane. Research by (Purwanto & Anshori, 2021) revealed that if students still fail to understand the basic concept of hydrocarbon compound material. Students will inevitably have difficulty understanding the next chapter, which includes cycloalkanes, alkenes, and alkdiene, as well as alkynes.
5	General reactions of hydrocarbons The reaction below is an example of an additive reaction.  	Students know the concept of hydrocarbon compound reactions which is often quite difficult to understand because: (1) hydrocarbon reactions produce more than one type of product, (2) some hydrocarbon compound reactions have mechanisms with more than two stages, and (3) alkanes, alkenes, and alkynes. 
6	Isomer pair identification In 1-butene compounds isomer position with 2-butene	There are still students who have misconceptions about the placement of double groups, and there are those who think that positional isomers are isomers that have different functional groups. Position isomers are compounds with the same molecular formula and functional group, but have different group positions (Chang, 2010) in (Vellayati et al., 2020).
7	Isomer pair identification C3H8O compounds can be alkhohol and ether and are functional isomers	There are still some misconceptions. Among them, there are those who consider that functional isomers are the same, the molecular formula is the same, and the functional groups are the same. There are also those who still think it is wrong and are not sure. There is also something wrong in describing the structure. 
8	Identification of the chiral center of the compound. Compound 2,3 dichlorobutane has 2 chiral centers	Some have been able to describe that carbon atoms bonded to four different substituents are chiral conditions, but many misconceptions arise when students prove where the chiral center is. The compound 2,3 dichlorobutane has 2 chiral centers in the atoms C No. 2 and C No. 3 with bonded subsituents namely -CH3, Cl, H.

9	Stereoisomer concept Geometric isomers occur only in alkene compounds	Geometric isomers occur not only in alkene compounds, but also cycloalkanes. Misconceptions arise when students are unable to explain. Some think that geometric isomers can occur in alkyne compounds. Research (Djarwo, 2018) and (Purwanto, 2021) shows that there is still a misunderstanding of the concept on the topic of alkene geometric isomers.
10	The compounds below are examples of elimination reactions 	Most of them answered correctly and confidently, the answers expressed were in accordance with the theory  However, students do not understand the results of the elimination process and the product. The elimination reaction is the reaction of the removal of 2 atoms/ groups from the molecule. This reaction results in pi bonds. The reaction on the side is the substitution reaction. Research (Belachew, 2020) shows that college students have difficulty distinguishing between substitution and addition reactions, and they often misunderstand the typical reactions in alkanes, alkenes, and alkynes.

The representation of the table above can be seen in Figure 1. The information in Figure 1 shows how the level of mastery of the concept of organic chemistry on the topic of characteristics of hydrocarbon compounds and compound isomers.

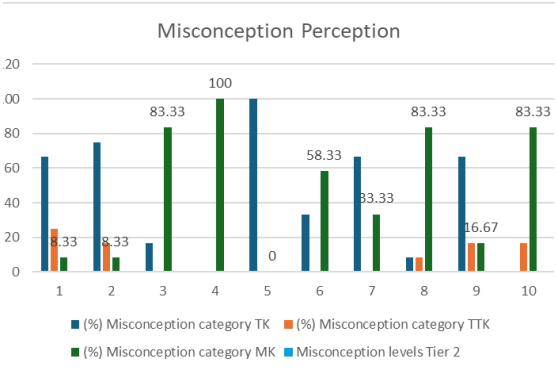


Figure 1. Percentage Misconception Diagram

Based on the information in the figure above, the question items that experienced high misconceptions were in numbers 3, 4, 6, 8, and 10, namely in the understanding of the concept of physical and chemical properties of hydrocarbon compounds, the nomenclature of hydrocarbon compounds, the understanding of chemical reactions, isomers and chirality of compounds.

In the concept of the physical properties of hydrocarbons, students still have difficulty in understanding the melting point and boiling point of compounds, considering that the boiling point increases along with the increase of alkyl and decreases when the relative molecular mass is larger. The correct theory is that this increase in the boiling point is due to the increased Van Der Walls attraction between longer molecules. Thus, the homologous series also exhibit similar characteristics for gaseous (C1-C4), liquid (C5-C18), and solid (C>18) carbon chains. Branching in the hydrocarbon compound section also affects the descent of the boiling point of the hydrocarbon compound because the Van Der Walls tensile force between the molecules in the phase can be disrupted (Rico & Fitriza, 2021).

Misunderstanding of the concept of structure and nomenclature of hydrocarbon compounds arises because students still assume that the numbering of hydrocarbon compounds that

have a double starts from the end closest to the alkyl group (Ubanwa, 2016). Similar with (Pratiwi et al., 2023) found that 24.7% of students understood hydrocarbon concepts well, and 43.2% of students had misconceptions about hydrocarbons. Some students also still have difficulty showing the sequence of main chain numbers in hydrocarbon compounds. When cycloalkenes are named, the highest number is always given to the alkyl group attached to the ring (Sendur, 2012).

The concept of hydrocarbon compound reactions also has misconceptions, including: 1) students still assume that the elimination reaction changes the double to the non-double (Herunata et al., 2020); 2) substitution reaction is a substitution reaction without knowing what to replace in a hydrocarbon reaction; 3) addition is a reaction that does not change the double bond in the alkene and a reaction that does not change the double bond to a single (Deska Dewati, 2016). The addition of the reaction can only occur in compounds that have π bonds. Markovnikov's rule can always be used to predict when HX is added to an asymmetrical alkene. The most appropriate concept of the reaction of hydrocarbon compounds should be as follows: a substitution reaction in which one group is replaced by another, elimination reactions in which two groups are drawn from two adjacent carbon atoms, thus forming a double bond, and an addition reaction in which two groups are drawn from two adjacent carbon atoms, adding one group to two carbon atoms with a double bond, eliminating their double bonds (Sendur, 2012a).

Previous research (Purwanto & Fathul Jadid Anshori, 2021) and (Lestari, 2021) revealed that isomer materials still have not reached full completeness, namely in the type of compound functional group and the type of carbon compound reaction. Students' understanding of the concept of stereochemistry is still low. Students understand the concept of isomer types, but they still have difficulty naming them and are not yet able to recognize and distinguish each functional group. Conceptual errors in the isomerization of hydrocarbon compounds also arise because students are still unable to understand molecular formulas and structural formulas (Rico & Fitriza, 2021).

Hansen in (Permatasari, 2021) states that basically misconceptions are different from errors, because errors are mistakes made due to carelessness, misinterpretation of questions, and lack of experience in solving problems related to a given topic. If a systematic error is due to using the wrong rules or the right rules but used outside the application, it is called a misconception. If this is not addressed immediately, it will obviously have an impact on future learning.

A combination of methods is needed to obtain reinforcement of data similar to this topic, namely the Systematic Literature Review method using VOS data. From 311. 734 articles were selected according to abstract and title to 735 articles. Search results using the keywords misconception, hydrocarbons, diagnostic test, three tier, prospective science teachers connected with boolean operators "and" and "or". Then, to strengthen the deepening of the novelty of this misconception research, the data visualization based on articles obtained from Scopus can be seen in the following Figure 2.

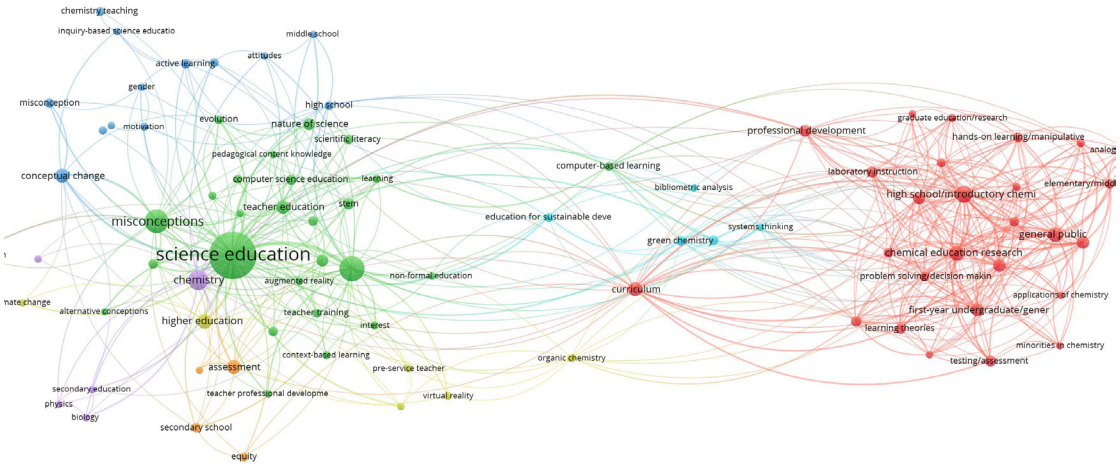


Figure 2. Network visualization based keyword" Misconception using diagnostic test in chemistry in science education" from Scopus

Furthermore, with consideration of the inclusion criteria, among others: (1) Articles on chemical misconceptions; (2) publications between 2015-2025; (3) articles are Final; (4) accredited and reputable publications; (5) open access, which when kurated into 10 articles. From SLR obtained more informative summaries or research syntheses as well as comprehensive research critiques. Therefore, the discussion of this article can be linked to the literature review by using scispace referencing the columns in Table 7 below in order to detect and correct these beliefs, current research has used a variety of diagnostic techniques, most notably three-tier examinations. This method provides a thorough grasp of students' conceptual grasp by evaluating not only their knowledge but also their reasoning and confidence in their responses.

Table 7. Data Systematic Literature Review (SLR) indexed DOAJ and scopus (2015-2025)

No	Journal Article	Journal	Methods used	Research Gap	Findings	Conclusions
1	Optimizing Preservice Chemistry Teachers Understanding in Reaction Related Concepts of Alipahtic Hydrocarbons (Belachew, 2020)	EURASIA Journal of Mathematics, Science and Technology Education, 2020	Case study method employed for in-depth investigation.	Limited focus on substitution and elimination reactions understanding.	Intervention Group showed improved understanding of AHC reactions.	Conceptual Change Texts improved understanding of aliphatic hydrocarbons.
			Conventional and Conceptual Change Instructional Approaches used.	Need for broader participant diversity in future studies.	Reduced Alternative Conceptions and increased Correct Conceptions in participants.	Reduced alternative conceptions and increased correct conceptions observed.
2	Determination of middle school students' misconceptions related to the unit of "structure and properties of matter" using a two-tier diagnostic test (Avcı et al., 2015)	Turkish Online Journal of Educational Technology, 2015	In order to evaluate students' misconceptions about the composition and characteristics of matter, the study uses a quantitative research design, especially a two-tier diagnostic test.	Regarding the particular misunderstandings that middle school pupils have about the composition and characteristics of matter, the study fills a sizable vacuum in the literature.	According to the study, a sizable portion of middle school pupils have false beliefs about the composition and characteristics of matter.	According to the study's findings, middle school pupils frequently hold false beliefs about the composition and characteristics of matter, which can make it more difficult for them to comprehend basic scientific ideas.
				Although generic fallacies in science education may have been found in earlier studies, this study focusses on a particular age group and curriculum area.	Misconceptions regarding the nature of matter, atomic structure, and the connection between structure and attributes are among the specific ones that have been found.	
3	Minimizing misconception of ionization energy through three-tier diagnostic test (Suprapto et al., 2018)	Periodico Tche Quimica, 2018	The study employs a quantitative research design utilizing a three-tier diagnostic test to assess and minimize misconceptions related to ionization energy among students	The study fills a major vacuum in the literature by examining the particular misunderstandings that students have concerning ionisation energy, a difficult chemistry term. It's possible that earlier studies concentrated on broad misunderstandings in chemistry instruction rather than specifically addressing ionisation energy.	According to the study, a lot of students have misconceptions about ionisation energy, including misconceptions about the term itself and the variables influencing it.	To effectively detect and correct misconceptions, the authors advise teachers to incorporate three-tier diagnostic assessments into their lesson plans. This will enable them customise their training to each student's needs and improve their conceptual comprehension.

4	Exploring the Actual and Potential Rhetoric-reality Gaps in Environmental Education and their Implications for Pre-service Teacher Training (Grace & and Sharp, 2000)	Environmental Educational Research, 2000	Interviews with teachers Comparison of advocated components with school practices	There is little data on the environmental education strategies that instructors propose. There is still much to learn about potential rhetoric-reality gaps in many locales.	Identified actual and potential rhetoric-reality gaps in environmental education. Explored teachers' views on selected components of environmental education.	Rhetoric-reality overlap is more accurate than gap. Pre-service teacher training should focus on effective EE delivery.
5	Diagnostic assessment of elementary school pupils' understanding of aliphatic hydrocarbons by using a three-tier test (Grace & and Sharp, 2000)	Inovacije u nastavi, Serbia, 2000	Three-tier diagnostic test for assessment Ten-item test completed by 114 pupils		51.75% to 63.16% showed satisfactory understanding on seven items. Less than 40% understood chemical reactions of aliphatic hydrocarbons.	Satisfactory understanding varies among pupils on aliphatic hydrocarbons. Misconceptions detected in over 10% of pupils.
6	Misconceptions and biases in German students' perception of multiple energy sources: implications for science education (Lee, 2016)	International Journal of Science Education, 2016	The study employs a mixed-methods approach, combining quantitative surveys and qualitative interviews to explore students' perceptions of various energy sources.	The study fills a major vacuum in the literature about students' knowledge of energy sources, especially when it comes to Germany. Although misunderstandings in science education have been the subject of prior studies, little attention has been paid to how students see and assess various energy sources.	According to the study, a large number of German students have false beliefs about a variety of energy sources, such as the viability, environmental impact, and efficiency of renewable energy in comparison to fossil fuels.	According to the study's findings, German students frequently hold preconceived notions and biases about energy sources, which might hinder their comprehension of significant energy-related scientific and societal concerns.
7	Empowering professional learning communities of secondary science teachers to uncover and address their students' misconceptions via research-oriented practices	Frontiers in Education 2024	The study employs a qualitative approach, focusing on the establishment of Professional Learning Communities (PLCs) among secondary science teachers. The PLCs are designed to facilitate teacher-led inquiry and action research.	Study fills a major vacuum in the literature by examining the discrepancy between classroom practice and educational research, especially in scientific education. It emphasises the necessity of ongoing, cooperative professional development enables educators to do action research in order to correct misconceptions held by students.	Teachers reported significant improvements in their ability to identify and address student misconceptions in scientific concepts through collaborative inquiry and action research.	By highlighting the value of teacher cooperation and action research in enhancing scientific instruction and clearing up student misconceptions, this study advances our understanding of effective professional development in education.
8	Determination of Science Teacher Candidates' Misconceptions on Liquid Pressure with Four-Tier Diagnostic Test (Taban & Kiray, 2021)	International Journal of Science and Mathematics Education, 2021	Four-tier misconception diagnostic test KR-20 reliability coefficient calculation		Science teacher candidates' scientific knowledge about liquid pressure is 15%.	Science teacher candidates have misconceptions, lack knowledge on liquid pressure.

9	Exploring Teachers' Understanding about Misconceptions of Secondary Grade Chemistry Students (Ilyas & Saeed, 2018)	International Journal for Cross-Disciplinary Subjects in Education (IJCDSE), 2018	Inquiry-based teaching Scientific explanation		Teachers understand misconceptions but lack knowledge on sources and remedies. Teachers do not consider misconceptions in lesson planning.	Teachers understand the terminology of misconceptions but lack knowledge about their sources and rectification techniques. Teachers do not consider possible misconceptions that could arise from their teaching.
10	Refutation texts: Implying the refutation of a scientific misconception can facilitate knowledge revision (Weingartner & Masnick, 2019)	Contemporary Educational Psychology, 2019	The study employs an experimental design to investigate the effectiveness of refutation texts in facilitating knowledge revision among students with pre-existing scientific misconceptions.	The study fills a major vacuum in the literature by examining the ways in which refutation texts might successfully encourage knowledge revision. Although the usage of refutation texts has been studied in the past, little study has been done on how students' comprehension is affected by implied versus explicit rejection.	The findings suggest that teachers can assist students in dispelling misconceptions by incorporating implied refutation techniques into their lesson plans. This strategy might be especially helpful in situations where confronting misconceptions head-on could cause resistance or defensiveness.	According to the study's findings, students' knowledge revision can be aided by the use of rebuttal texts, especially those that suggest rather than proclaim the debunking of errors. The design of instructional tactics and educational resources will be significantly impacted by this conclusion.

According to (Soeharto et al., 2019), physics, chemistry, and biology are the subjects that commonly cause misconceptions in students. Multiple tier tests are the most commonly used diagnostic instrument. To overcome the misconceptions that arise, the delivery of chemical material can use multiple representation-based media, for example videos, animations, power points and so on (Fitriani et al., 2023) the use of chemical narratives in daily life (Üce & Ceyhan, 2019) is also believed to reduce misconceptions because it will increase meaning. Teaching material by lecture method is not recommended in eliminating abstract chemical misconceptions. Programs for focused professional development that enhance pre-service teachers' PCK are necessary, especially when it comes to hydrocarbons. (Manarisip et al., 2023). Alternative beliefs about hydrocarbons continue to exist, according to research, which suggests that teaching methods that particularly address these misconceptions are necessary. (Belachew, 2020). Differences exist between hydrocarbon materials in both curricula. Teachers show limited variation in teaching hydrocarbon topics. Inconsistencies in the way hydrocarbon materials are taught are revealed by the use of many curricula, such as the Merdeka Curriculum, which suggests a lack of consistency in teacher preparation and resources (Naqsyahbandi et al., 2024). This similar with (Manarisip et al., 2023). Chemistry teacher competencies include PCK, CK, AK, and more are needed to overcome the misconception.

CONCLUSION

This research refers to the identification of misconceptions that arise in prospective science teacher students. Question items that contain an understanding of the concept of physical and chemical properties of hydrocarbon compounds, nomenclature of hydrocarbon compounds, understanding of chemical reactions, isomers and chirality of compounds have high misconceptions. Three-tier tests consist of multiple-choice questions, reasoning for answers, and confidence ratings, allowing for a nuanced assessment of student understanding. In one study, 81.2 prospective science teachers showed high misconceptions regarding naming, isomers, and chirality, highlighting the prevalence of misconceptions in basic concepts.Teachers appreciate the relevance of hydrocarbon themes but often struggle with different student backgrounds and limited resources, exposing a need in curriculum support. While these gaps are significant, it is also essential to consider that some studies suggest imp-

rovements in understanding through innovative teaching methods, indicating potential pathways for addressing these issues in teacher education.

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