Electronic Journal of Education, Social Economics and Technology
Vol. 6, No. 2, (2025), pp. 1~10, Article ID: 1063
ISSN 2723-6250 (online)
DOI: https://doi.org/10.33122/ejeset.v6i2.1063

SAINTIS publishing

Research Article

Diagnostic Analysis of Students' Hydrocarbon Concept Mastery Using Two-Tier Multiple Choice Test

Mislawati, Isna Rezkia Lukman*, Ade Masyithah, Mifla Hayatul, Mas Mudah Nazwa, Halimatus Sakdiah

Faculty of Teachers Training and Education, Universitas Malikussaleh, Aceh Utara, Indonesia, 24351
*Corresponding Author: rezkia.lukman@unimal.ac.id | Phone: +6281220237241

ABSTRACT

This study aims to analyze learning difficulties in relation to students' levels of conceptual understanding—categorized as conceptually understood, misconceptions, and lack of understanding among 11th-grade science students (Grade XI MIPA) in the Teupah Barat District, specifically concerning the topic of hydrocarbons. A Two-Tier Multiple Choice diagnostic test was employed as the primary instrument. The study utilized a qualitative descriptive method. The population comprised all Grade XI MIPA students from senior high schools in the Teupah Barat District. The sample included 40 students from SMA Negeri 1 Teupah Barat and SMA Negeri 2 Teupah Barat, selected using purposive sampling techniques. Data analysis was conducted using descriptive statistics to process and interpret the students' responses. The results indicate that the Two-Tier Multiple Choice diagnostic test was effective in identifying students' conceptual understanding and in uncovering alternative conceptions through dominant incorrect answer choices that diverged from scientifically accurate concepts.The findings reveal that among the participants, 64% demonstrated conceptual understanding, 23% exhibited misconceptions, and 13% showed a lack of understanding regarding the topic of hydrocarbons. These results highlight the diagnostic tool's utility in pinpointing areas where conceptual reinforcement is necessary to enhance students' comprehension in chemistry education.

Keywords: Hydrocarbon; Understanding; Two Tier Test; Multiple Choice Test; Diagnostic;

1. INTRODUCTION

Education is a conscious and well-planned effort to create a learning environment and process that actively enables students to develop their full potential, including spiritual and religious strength, self-control, personality, intelligence, noble character, and the skills required by themselves, society, the nation, and the state (Ichsan, 2021; Yulianto, 2020). However, students may encounter conceptual misunderstandings that stem from the way they construct knowledge. These misconceptions often arise due to prior knowledge that is incompatible with scientifically accepted perspectives, particularly in the subject of chemistry, which is a branch of natural science frequently perceived as difficult due to its complex and abstract concepts. A considerable number of students study chemistry, yet many struggle to grasp its fundamental concepts. Based on the results of an observational analysis of the test score recap for students of Class XI MIPA 1 at SMA Negeri 1 Teupah Barat during the odd semester, as presented in Appendix 11, it was found that 75% of the 24 students scored below the Minimum Mastery Criteria (KKM) of 70 on their daily tests. This outcome indicates a lack of students' conceptual understanding of the chemistry topics being taught. Chemistry education often presents challenges due to the abstract nature of its concepts, leading to persistent misconceptions among students. Hydrocarbons, fundamental to organic chemistry, are particularly susceptible to such misunderstandings, which can hinder students' ability to grasp more complex topics in the discipline (Qodriyah et al., 2020).

Understanding is defined as the ability to apply previously acquired knowledge in a manner consistent with how it was taught and aligned with its intended use (Alfiani & Firmansyah, 2022). According to Aminati & Ma'rufah (2019), understanding can be categorized into three levels: translation, interpretation, and extrapolation. Similarly, Sudjana (2009) classifies understanding into three levels based on the depth of comprehension: the first (lowest) level, the second level, and the third (highest) level. Furthermore, the factors influencing understanding are generally divided into two categories: internal factors and external factors. To effectively identify and address these misconceptions, diagnostic assessments have become essential tools in educational research. Among these, the two-tier multiple-choice test stands out for its ability to evaluate not only the correctness of students' answers but also the reasoning behind them, providing deeper insights into their conceptual understanding(Maison et al., 2019).

The two-tier multiple-choice test is an objective assessment format that consists of an incomplete statement or definition, which the test-taker must complete by selecting the most appropriate answer from several given options. These options typically include one correct answer and several distractors (Arikunto, 2012). Reasoned multiple-choice questions can be classified into types based on interrelated components, such as correlational multiple-choice items, in which each question consists of two statements that are logically connected (Suwarto, 2013).

The advantages of using the Two-Tier Multiple-Choice instrument include facilitating researchers in identifying the difficulties faced by students, reducing the likelihood of students answering by guessing, saving time, and motivating students to find the correct answers. However, in addition to these benefits, the application of Two-Tier Multiple Choice also has its drawbacks. The availability of closed-answer choices and justifications means that there is a possibility for students to guess answers at both levels (Laksono, 2020). The role of a teacher is crucial in supporting students throughout the learning process (Ermindyawati, 2019). Teachers need to monitor students' progress and identify any difficulties they may encounter in understanding concepts. This calls for a diagnostic activity. One effective form of diagnostic assessment is the use of a two-tier multiple-choice diagnostic test. This type of instrument enables teachers to evaluate students' conceptual understanding and categorize their level of comprehension based on their responses. However, despite these benefits, the TTMC format also has its limitations. Since both answer options and reasons are provided in a closed-ended format, there remains the possibility that students may still resort to guessing at both tiers.

The mastery of hydrocarbon concepts among students remains a significant challenge in chemistry education, often characterized by persistent misconceptions and superficial understanding. Diagnostic analysis using two-tier multiple choice tests has been widely employed to identify not only students' knowledge accuracy but also the reasoning behind their answers, revealing critical gaps in conceptual comprehension (Ningrum et al., 2020; Roudloh et al., 2023) A recurrent issue is students' reliance on rote memorization rather than a deep understanding of the fundamental relationships within hydrocarbon structures, properties, and reactions, which impairs their ability to apply knowledge in different contexts (Primasari et al., 2021)). Moreover, difficulties in connecting hydrocarbon concepts to real-life phenomena contribute to diminished student engagement and motivation (Sumarni et al., 2019; Zandroto & Sinaga, 2022). Traditional teaching methods predominantly emphasize theoretical knowledge transmission, which often neglects students' conceptual difficulties and results in a high incidence of misconceptions, particularly related to chemical bonding and classification of hydrocarbons (Azizah et al., 2022) The two-tier diagnostic tests consistently expose misunderstandings in identifying types of bonds and chemical behaviors specific to various hydrocarbon compounds (Taher, 2022) Additionally, there is an observed deficiency in fostering critical thinking skills during hydrocarbon instruction, limiting students' ability to analyze and reflect on concepts at a deeper level (Kainde & Tahya, 2020)

Another significant challenge is the lack of contextual and applied learning materials, which causes the hydrocarbon topics to appear abstract and detached from students' everyday experiences. Insufficient use of innovative and interactive learning media further hinders the internalization of concepts, leading to incomplete understanding (Nasarudin et al., 2023; Rahmawati et al., 2022). Consequently, the implementation of two-tier multiple-choice tests as diagnostic tools is critical in revealing detailed insight into students' misconceptions and mastery levels, enabling educators to design targeted remediation strategies effectively (Iriyadi et al., 2022). Recent studies have also indicated that the incorporation of contextual learning approaches combined with technology-enhanced instruction significantly reduces misconceptions and improves students' conceptual understanding of hydrocarbons (Kartini & Putra, 2022). However, the adoption of these methods remains limited due to inadequate teacher training and resource constraints, highlighting the need for professional development to empower educators with innovative pedagogical tools (Lestari & Kurnia, 2023)

Recent studies have employed two-tier diagnostic tests to uncover misconceptions in various scientific domains. For instance, research has highlighted the prevalence of misconceptions in topics like chemical bonding and thermodynamics, emphasizing the need for targeted instructional strategies. In the context of hydrocarbons, similar diagnostic approaches have revealed significant gaps in students' understanding, underscoring the importance of such assessments in curriculum development (Didik et al., 2020). In addition, a study by Lukum et al. (2023) utilized a two-tier diagnostic test to analyze students' conceptual understanding of acid-base topics, demonstrating the effectiveness of this approach in identifying levels of student comprehension. Another study by Devi & Azra (2023) developed an image-based two-tier diagnostic test to identify students' misconceptions related to acid-base concepts. The use of the Two-Tier Multiple-Choice instrument offers several advantages, including facilitating researchers in identifying students' learning difficulties, reducing the likelihood of students answering through guessing, saving time, and encouraging students to actively seek correct answers. Despite these strengths, the application of the Two-Tier Multiple-Choice format also has limitations. The presence of closed-ended options for both answers and justifications still allows for the possibility that students may guess responses at both levels.

Based on the aforementioned background, this study aims to investigate " Diagnostic Analysis of Students' Hydrocarbon Concept Mastery Using Two-Tier Multiple-Choice Test " The objective of this research is to analyze learning difficulties in relation to students' levels of conceptual understanding, including conceptual understanding, lack of understanding, and misconceptions. This analysis focuses on Grade XI science students in senior high schools across Teupah Barat District, specifically in relation to the concept of hydrocarbons, using the Two-Tier Multiple Choice Diagnostic Test as the assessment instrument.

2. RESEARCH METHOD

The research employed a qualitative descriptive method. This study was conducted in August during the odd semester of the 2019/2020 academic year in Teupah Barat District, one of the districts located in Simeulue Regency. The population consisted of all 11th-grade science (MIPA) students from senior high schools in Teupah Barat, totaling 72 students—48 from SMA Negeri 1 Teupah Barat and 24 from SMA Negeri 2 Teupah Barat. The sampling technique used in this study was purposive sampling. Data were collected through the administration of a test, specifically utilizing a diagnostic instrument in the form of a Two-Tier Multiple-Choice test. This test instrument was administered to a sample of 40 students who served as the research subjects. The Two-Tier Multiple-Choice test comprises two parts. The first tier contains multiple-choice questions with several answer options, while the second tier consists of reasoning items corresponding to the selected answers in the first tier. This structure allows for a more in-depth assessment of students' conceptual understanding and reasoning.

3. RESULTS AND DISCUSSION

3.1 Results

The results of the trial test instrument developed by the researcher to be used as the research instrument are presented in the form of tables and graphs. The instrument, consisting of test items, was initially piloted with students who had previously received instruction on hydrocarbons, specifically students from Grade XII MIPA-1 and MIPA-2 at SMA Negeri 1 Teupah Barat. A total of 25 two-tier multiple-choice items were administered, with an allotted completion time of 90 minutes. Following the pilot administration, the test results were analyzed to identify items suitable for inclusion in the final research instrument. The analysis included item validity, reliability, discrimination index, and difficulty level. The following section presents the item analysis results from the pilot test, including the calculation of item validity.

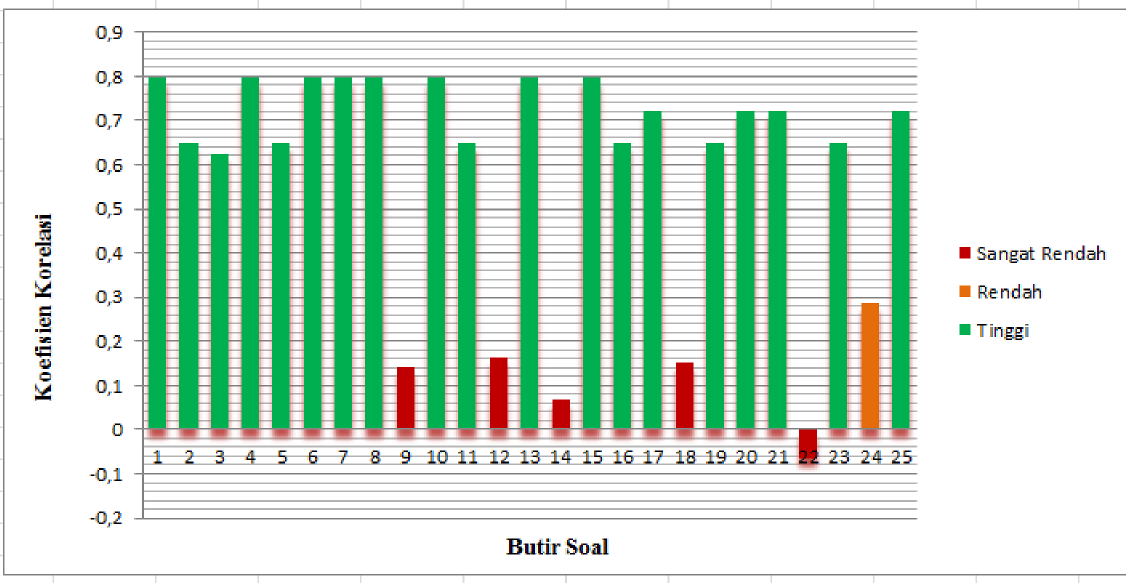


Figure 1. Interpretation of Validity Testing

Reliability testing was conducted subsequent to the validity testing of the test instrument. The analysis involved comparing the obtained r_{11} value with the critical value from the r-table. The instrument is considered reliable if the r_{11} value exceeds the r-table value (r_{11} > r-table). The results of the reliability calculation are presented in the **Table 1.**

Tabel 1. Reliability Test Results of the Test Instrument

Test Type	Reliability Coefficient	r Table	Reliability Level
Two tier multiple choice diagnostic test	0,910	0,3598	High

The following presents the results of the difficulty index calculations for the test instruments (see in **Figure 1**)

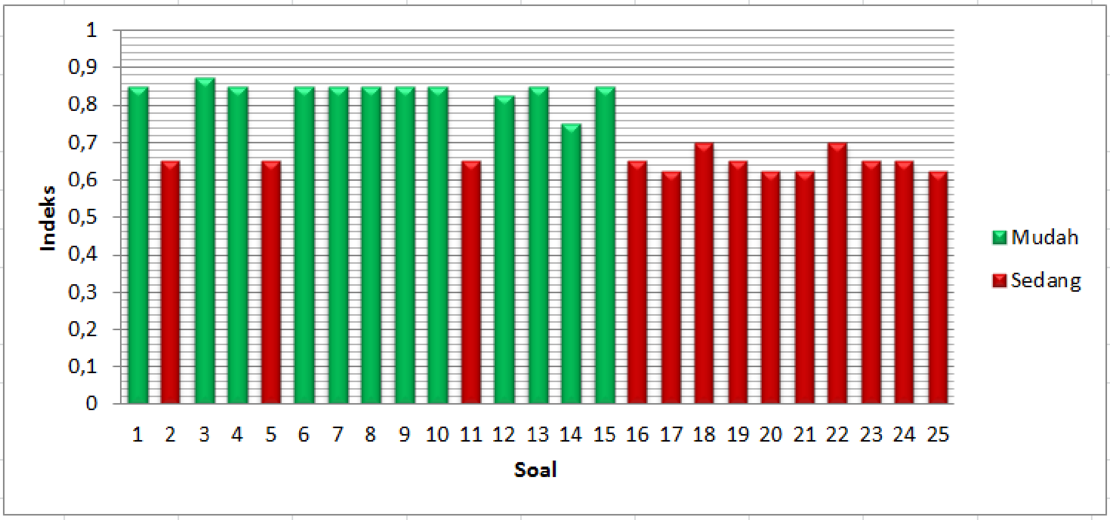


Figure 2. Interpretation of Difficulty Level Test

The following presents the data from the item discrimination trial of the test instrument, as illustrated in **Figure 3.**

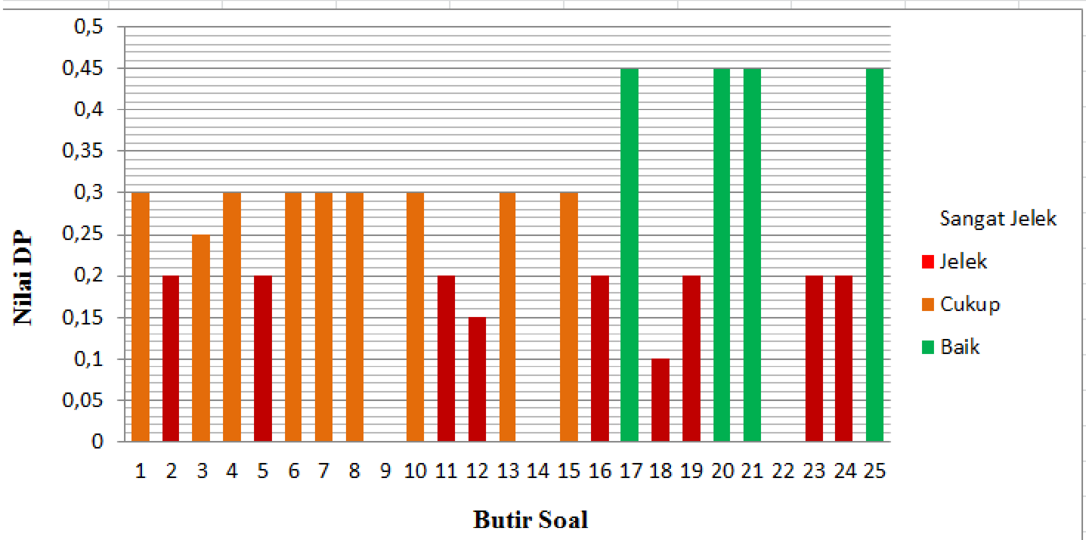


Figure 3. Interpretation of Discrimination Power Test

The results of the research test conducted to analyze students' conceptual understanding—categorized into concept mastery, misconceptions, and lack of understanding regarding the topic of hydrocarbons were obtained using a two-tier multiple-choice diagnostic test. The data are presented in the form of tables and graphs. A total of 19 multiple-choice questions were administered, covering seven sub-concepts: hydrocarbon compounds, the uniqueness of carbon atoms, types of carbon atoms, classification of hydrocarbons, properties of hydrocarbons, hydrocarbon isomerism, and reactions of hydrocarbon compounds. The test was given to 40 eleventh-grade science students (Class XI MIPA) with an allotted time of 90 minutes. After processing the data, the results were categorized based on students' responses, as shown in the following **Table 2**.

Based on the **Table 2**, in the category of conceptual understanding, the highest percentage was observed in the concept of hydrocarbon compounds at 77.5%, while the lowest was found in the concept of the uniqueness of carbon atoms at 55.83%. In the category of misconceptions, the highest percentage occurred in the concept of the uniqueness of carbon atoms at 32.50%, whereas the lowest was in the concept of hydrocarbon compound reactions at 12.50%. In the final category, lack of conceptual understanding, the highest percentage was recorded in the concept of hydrocarbon isomerism at 20.83%, while the lowest was in the concept of types of carbon atoms at 6.25%.

Tabel 2. Student Answer Categories by Hydrocarbon Concepts

No	Concept	Answer Category (%)		
		Understand (B – B)	Miskonsepsi (B – S, S – B)	Do Not Understand (S – S)
1	Hydrocarbon Compounds	77,5	15	7,5
2	Uniqueness of Carbon Atoms	55,83	32,50	11,67
3	Types of Carbon Atoms	62,5	31,25	6,25
4	Classification of Hydrocarbons	60	30	10
5	Properties of Hydrocarbons	59,17	21,67	19,17
6	Hydrocarbon Isomerism	60,83	18,33	20,83
7	Reactions of Hydrocarbon Compounds	71,25	12,50	16,25
	Total	447,08	161,25	91,67
	Average	63,87	23,04	13,10

In the category of concept understanding, five hydrocarbon concepts were identified with percentages below the overall average. In the misconception category, four hydrocarbon concepts also exhibited percentages lower than the total average—namely hydrocarbon compounds, properties of hydrocarbons, hydrocarbon isomerism, and reactions of hydrocarbon compounds. Lastly, in the category of lack of concept understanding, four concepts were found to fall below the overall average, specifically hydrocarbon compounds, the uniqueness of carbon atoms, types of carbon atoms, and hydrocarbon classification. A comparative analysis of each response category across the sub-concepts is presented in the following figure, which illustrates their distribution in relation to the entire hydrocarbon material. In the context of hydrocarbon compounds, the percentage of students demonstrating conceptual understanding reached 77.5%. This indicates that the majority of students have a general comprehension of the concept of hydrocarbon compounds. Meanwhile, 15% of the students exhibited misconceptions, and 7.5% showed a lack of conceptual understanding. The following is an example of a test item that highlights student errors related to the concept of hydrocarbon compounds.

In test item number 2, students who possess a general understanding of the concept were able to categorize compounds classified as hydrocarbons. However, analysis of responses to this item identified three students who made errors in the first-level question by selecting option A. These students understood that hydrocarbons are compounds containing carbon (C) and hydrogen (H) atoms. Nevertheless, they lacked sufficient understanding to accurately classify the given compounds into the hydrocarbon category. Furthermore, there were three responses that indicated a conceptual misunderstanding, as evidenced by the selection of options A through D. These students mistakenly believed that hydrocarbons are compounds composed of carbon (C), hydrogen (H), and oxygen (O) elements. In fact, hydrocarbons are ideally defined as compounds consisting solely of carbon and hydrogen atoms. The presence of other elements, such as oxygen, would classify the substance as an organic compound, but not a hydrocarbon.

In the context of students' understanding of the uniqueness of carbon atoms, 55.83% of the participants demonstrated a sound conceptual understanding, indicating that the majority have grasped the core concept. However, 32.50% were identified as having misconceptions, while 11.67% fell into the category of lacking conceptual understanding. Below is an example of a test item designed to identify student errors regarding the uniqueness of carbon atoms. In question number 4, students were asked to determine the group and period of the carbon atom by applying electron configuration based on its atomic number. In this item, nine students were found to have made errors categorized as Level 1, choosing option B. These students understood the concept of electron configuration but were unable to correctly determine the group and period from it. Additionally, three students made Level 2 errors, selecting options 2E and 1D. These errors suggest that while the students had memorized the group and period of carbon, they did not understand how to derive this information from the electron configuration.

In the concept of carbon atom types, the percentage of students categorized as understanding the concept was higher than the other categories, reaching 62.5%. This indicates that the majority of students had a good grasp of the concept of carbon atom classification. However, the percentage of students with misconceptions was relatively high, at 31.25%, while 6.25% were classified as not understanding the concept. Below is an example of a question used to identify students' misconceptions regarding the concept of carbon atom types. In this item, 11 students were identified as providing incorrect answers at level 1. Specifically, 7 students selected option D, and 4 students selected option B. These errors occurred because the students failed to differentiate the hydrogen atoms bonded to the carbon atom labeled number 5, which led to the incorrect assumption that this carbon atom was bonded to four other atoms. Furthermore, the students were unable to distinguish between the definitions of primary, secondary, tertiary, and quaternary carbon atoms, which are based on the number of carbon-carbon bonds.

2) 1. The following compounds are known:

I. CH_3CH_2OH

II. C_3H_4

III. $CH_3CHCH(CH_3)_2CH_3$

IV. C_2H_5OH

V. $C_{12}H_{22}O_{11}$

Compounds that are classified as hydrocarbons are ....

A. I and IV

B. II and III

C. III and IV

D. III and V

E. Only II

2. To complete question 2.1, the correct statement is...

A. Hydrocarbon compounds have an OH group.

B. Hydrocarbon compounds consist of elements C and H.

C. Hydrocarbon compounds consist of elements C and O.

D. Hydrocarbon compounds consist of elements C, H, and O.

E. Hydrocarbon compounds consist of many C elements.

Figure 4. Test Question Number 2

4) 1. A carbon compound is a compound that consists of carbon atoms. A carbon atom with atomic number 6 is located in the group and period...

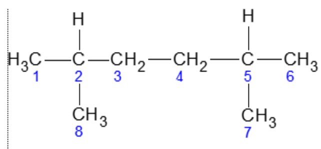
A. I A / 1
B. II B / 4
C. IV A / 2
D. IV A / 4
E. V B / 4

2. To complete statement 4.1), the correct reason is...

A. Has the electron configuration $1s^1$
B. Has the electron configuration $1s^2\ 2s^2\ 2p^2$
C. Has the electron configuration $[Ar]\ 3d^{10}\ 4s^2$
D. Has the electron configuration $[Ar]\ 3d^{10}\ 4s^2\ 4p^2$
E. Has the electron configuration $[Ar]\ 3d^3\ 4s^2$

Figure 5. Test Question Number 4

8) 1. Pay attention to the structure of the following compound.



Pay attention to the structure of the following compound.
The type of carbon atom indicated by number 5 is....
A. Primary
B. Secondary
C. Tertiary
D. Quaternary
E. Primary and Tertiary

2. To complete question 8.1), the correct statement is...
A. The carbon atom is bonded to one other carbon atom
B. The carbon atom is bonded to two other carbon atoms
C. The carbon atom is bonded to three other carbon atoms
D. The carbon atom is bonded to four other carbon atoms
E. The carbon atom is bonded to all carbon atoms in the longest chain

Figure 6. Test Question Number 8

In the concept of hydrocarbon classification, 60% of students demonstrated conceptual understanding, 30% exhibited misconceptions, and 10% showed a lack of understanding. In question number 10, students were instructed to identify the homologous series of hydrocarbon compounds based on the given molecular formulas. In this question, it was identified that 17 students provided incorrect answers at level 2, choosing option D. The students' errors stemmed from a misunderstanding of the general formula for alkynes, as they prioritized memorization over conceptual comprehension of the differences between the general formulas of alkanes, alkenes, and alkynes. Additionally, 8 students selected incorrect options (A-B) on both items. This mistake was due to their lack of understanding regarding homologous series and the general formulas of alkanes, alkenes, and alkynes.

In the concept of hydrocarbon properties, 59.17% of students demonstrated a proper understanding, indicating that the majority of students have grasped the concept well. Meanwhile, 21.67% fell into the misconception category, and 19.17% were categorized as not understanding the concept at all. In question number 13, most students generally understood the concept of hydrocarbon properties; however, six students still showed a lack of understanding. Four students selected option D-A, and two chose option B-C, resulting in incorrect answers at both levels of the question. This error occurred because students assumed that compounds with more branches have more complex and harder-to-break bonds, thus requiring more energy to break them. Consequently, they believed these compounds would have higher boiling points. In the context of hydrocarbon isomerism, the percentage of students who demonstrated a proper understanding of the concept was 60.83%, indicating that the majority of students had grasped the concept well. Meanwhile, 18.33% of students fell into the misconception category, and 20.83% were categorized as not understanding the concept— a percentage notably higher than that of the misconception group. In question number 15, five students were identified to have made errors at level 1 by choosing option A, while two students made errors at level 2 by selecting option C. These errors were attributed to a misunderstanding of the concept of positional isomers and difficulty in accurately drawing molecular structures, which led to challenges in identifying the positional isomer of 2-butene. Additionally, three students made errors at both levels by consistently choosing option C–C. A learning process that prioritizes memorization over conceptual comprehension significantly affects student understanding, as rote learning without genuine understanding tends to be short-lived. The following item illustrates the types of errors made by students in understanding the concept of hydrocarbon isomerism.

In the context of hydrocarbon compound reactions, 71.25% of students demonstrated a proper conceptual understanding. Generally, students showed a good grasp of the concept of hydrocarbon isomerism. Meanwhile, 12.5% were categorized as having misconceptions, and 16.25% were classified as lacking conceptual understanding. In item number 19, students were instructed to identify the name of a given reaction. In this item, four students were identified as having a conceptual error at the first-tier question level, selecting option D as their answer. Additionally, seven students exhibited errors at both tiers of the question, selecting the D-A combination. These misconceptions arose from the belief that a reaction involving the conversion of a double bond into a single bond constitutes an elimination reaction. This misunderstanding likely stems from students' misapplication of the principle of elimination, which they interpreted merely as a reduction or removal of bonds, without fully understanding the actual meaning and mechanism of an elimination reaction.

3.2 Discussion

The results of data analysis indicate that the Two-Tier Multiple Choice diagnostic test is effective in identifying students' conceptual understanding by categorizing their levels of comprehension into three groups: conceptual understanding, misconceptions, and lack of understanding. Additionally, this instrument is capable of tracing students' alternative conceptions through the most frequently chosen incorrect answers that deviate from scientifically accepted concepts. A significant number of students were found to struggle particularly with questions involving molecular structure. This difficulty stems from the abstract and symbolic nature of molecular representations, which are not easily connected to students' everyday experiences. Abstract and complex concepts are often misinterpreted, leading to a divergence from the intended conceptual understanding (Permatasari, 2021; Tahir et al., 2022; Triana, 2023). Consequently, questions related to molecular structures tend to trigger misconceptions and confusion among students. Furthermore, students also made frequent errors in questions requiring identification of homologous series using the general formulas of alkanes, alkenes, and alkynes, as well as in determining an element's period and group based on its electron configuration. These difficulties are largely attributed to students' reliance on rote memorization rather than meaningful conceptual learning. Learning that prioritizes memorization without understanding tends to be temporary and insufficient for long-term retention or deep comprehension.

4. CONCLUSION

Based on the findings and discussion from the diagnostic test using the Two-Tier Multiple Choice method conducted by the researcher in Teupah Barat District, the analysis revealed varying levels of students' conceptual understanding—categorized as conceptual understanding, misconceptions, and lack of understanding across all sub-concepts within the Hydrocarbon topic. The average percentage of students who demonstrated conceptual understanding was 64%, those with misconceptions were 23%, and those who lacked conceptual understanding were 13%. Within the "conceptual understanding" category, the highest level of comprehension was observed in the sub-concept of hydrocarbon compounds at 77.5%, while the lowest was in the uniqueness of carbon atoms at 55.83%. In the "misconceptions" category, the highest percentage was found in the uniqueness of carbon atoms sub-concept (32.50%), and the lowest in the hydrocarbon compound reactions sub-concept (12.50%). For the "lack of understanding" category, the highest percentage was observed in the isomerism of hydrocarbons sub-concept (20.83%), with the lowest in the types of carbon atoms sub-concept (6.25%). Following the identification of conceptual errors among students, it is necessary to implement remedial learning strategies that offer alternative concept explanations in order to reduce misconceptions. Moreover, educators and prospective teachers must design effective teaching strategies to facilitate meaningful learning experiences and enhance students' conceptual understanding of the subject matter.

RECOMMENDATIONS

The results of this research and study are expected to provide information, insight, and knowledge that will benefit readers and institutions.

ACKNOWLEDGEMENTS

This paper and the research that underpins it would not have been possible without the outstanding support of our teams at Chemistry Education at Malikussaleh University. We are also thankful for the insightful discussions we had with our colleagues. The generosity and expertise of everyone involved have significantly improved this study and helped me avoid many errors. Thank you all so much.

AUTHOR'S CONTRIBUTIONS

All authors discussed the results and contributed to from the start to final manuscript.

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

REFERENCES

Alfiani, H., & Firmansyah, D. (2022). Analisis Kemampuan Pemahaman Matematis Siswa Ditinjau dari Soal TIMSS. *Jurnal Ilmiah Dikdaya*, *12*(1), 55–60. https://doi.org/http://dx.doi.org/10.33087/dikdaya.v12i1.274

Aminati, F. R., & Ma'rufah, N. (2019). Pengaruh Emosi Terhadap Pemahaman Mahasiswa Pada Matakuliah Biokimia. *Oksitosin: Jurnal Ilmiah Kebidanan*, *6*(1), 50–63. https://doi.org/https://doi.org/10.35316/oksitosin.v6i1.344

Arikunto. (2012). *Prosedur Penelitian*. Rineka Cipta.

Azizah, N. L., Mahardiani, L., & Yamtinah, S. (2022). Analisis Miskonsepsi Dengan Tes Diagnostik Two-Tier Multiple Choice Dan In-Depth Interview Pada Materi Asam Basa. *Jurnal Pendidikan Kimia*, *11*(2), 168–177. https://doi.org/https://doi.org/10.20961/jpkim.v11i2.60345

Devi, N. A., & Azra, F. (2023). Pengembangan Instrumen Tes Diagnostik Untuk Melihat Gambaran Model Mental Peserta Didik Pada Materi Asam Basa. *Entalpi Pendidikan Kimia*, 16–26. https://doi.org/https://doi.org/10.24036/epk.v4i3.345

Didik, L. A., Wahyudi, M., & Kafrawi, M. (2020). Identifikasi Miskonsepsi Dan Tingkat Pemahaman Mahasiswa Tadris Fisika Pada Materi Listrik Dinamis Menggunakan 3-Tier Diagnostic Test. *Journal of Natural Science and Integration*, *3*(2), 128–137. https://doi.org/http://dx.doi.org/10.24014/jnsi.v3i2.9911

Ermindyawati, L. (2019). Peranan Guru Pendidikan Agama Kristen terhadap Perilaku Siswa-Siswi. *FIDEI: Jurnal Teologi Sistematika Dan Praktika*, *2*(1), 40–61. https://doi.org/https://doi.org/10.34081/fidei.v2i1.27

Ichsan, F. N. (2021). Implementasi Perencanaan Pendidikan dalam Meningkatkan Karakter Bangsa melalui Penguatan Pelaksanaan Kurikulum. *Al-Riwayah: Jurnal Kependidikan*, *13*(2), 281–300. https://doi.org/https://doi.org/10.47945/al-riwayah.v13i2.399

Iriyadi, D., Rustam, A., & Ahmad, A. (2022). Integrasi Pembelajaran Remedial dan Tes Diagnostik. *Sulawesi Tenggara Educational Journal*, *2*(2), 78–86. https://doi.org/https://doi.org/10.54297/seduj.v2i2.253

Kainde, E. W., & Tahya, C. Y. (2020). Pemanfaatan Jurnal Refleksi Sebagai Penuntun Siswa Dalam Menemukan Makna Pada Mata Pelajaran Kimia. *Journal of Educational Chemistry*, *2*(2), 49–56. https://doi.org/10.21580/jec.2020.2.2.6076

Kartini, K. S., & Putra, I. N. T. A. (2022). Kebutuhan Pengembangan Media Pembelajaran Berbasis Android pada Materi Hidrokarbon. *Jurnal Edutech Undiksha*, *10*(1), 117–125. https://doi.org/https://doi.org/10.23887/jeu.v10i1.41877

Laksono, P. J. (2020). Pengembangan Three Tier Multiple Choice Test pada Materi Kesetimbangan Kimia Mata Kuliah Kimia Dasar Lanjut. *Orbital: Jurnal Pendidikan Kimia*, *4*(1), 44–63. https://doi.org/https://doi.org/10.19109/ojpk.v4i1.5649

Lestari, D. I., & Kurnia, H. (2023). Implementasi Model Pembelajaran Inovatif Untuk Meningkatkan Kompetensi Profesional Guru Di Era Digital. *JPG: Jurnal Pendidikan Guru*, *4*(3), 205–222. https://doi.org/https://doi.org/10.32832/jpg.v4i3.14252

Lukum, A., Karongkong, N., Pikoli, M., Tangio, J. S., Mohamad, E., & Kunusa, W. R. (2023). Analysis of Student's Conceptual Understanding Using Two-Tier Multiple Choice Diagnostic Test on Acid-Base Topic. *E3S Web of Conferences*, *400*. https://doi.org/10.1051/e3sconf/202340004003

Maison, M., Safitri, I. C., & Wardana, R. W. (2019). Identification Of Misconception Of High School Students On Temperature And Calor Topic Using Four-Tier Diagnostic Instrument. *Edusains*, *11*(2), 195–202. https://doi.org/https://doi.org/10.15408/es.v11i2.11465

Nasarudin, N. N., Samsi, S. A., Sarimuddin, S. S., & Mada, Z. M. Z. (2023). Efektivitas Pemanfaatan Multimedia Berbasis Adobe Flash Cs 6 dalam Meningkatkan Hasil Belajar Geografi di SMA Negeri 14 Bombana. *JPG (Jurnal Pendidikan Geografi)*, *10*(1). https://doi.org/http://dx.doi.org/10.20527/jpg.v10i1.14731

Ningrum, L. S., Supardi, K. I., Jumaeri, J., & Haryani, S. (2020). Pengembangan Karakter Religius Peserta Didik Melalui Pembelajaran Kimia Materi Hidrokarbon SMK. *Jurnal Inovasi Pendidikan Kimia*, *14*(1), 2490–2497. https://doi.org/https://doi.org/10.15294/jipk.v14i1.21335

Permatasari, K. G. (2021). Problematika Pembelajaran Matematika Di Sekolah Dasar/Madrasah Ibtidaiyah. *Jurnal Pedagogy*, *14*(2), 68–84. https://doi.org/https://doi.org/10.63889/pedagogy.v14i2.96

Primasari, I. F. N. D., Zulela, Z., & Fahrurrozi, F. (2021). Model Mathematics Realistic Education (RME) Pada Materi Pecahan Di Sekolah Dasar. *Jurnal Basicedu*, *5*(4), 1888–1899. https://doi.org/10.31004/basicedu.v5i4.1115

Qodriyah, N. R. L., Rokhim, D. A., Widarti, H. R., & Habiddin, H. (2020). Identifikasi Miskonsepsi Siswa Kelas XI SMA Negeri 4 Malang Pada Materi Hidrokarbon Menggunakan Instrumen Diagnostik Three Tier. *Jurnal Inovasi Pendidikan Kimia*, *14*(2), 2642–2651. https://doi.org/https://doi.org/10.15294/jipk.v14i2.24293

Rahmawati, T. A., Supardi, Z. A. I., & Hariyono, E. (2022). Pengembangan Media Pembelajaran Interaktif Berbasis Video Dengan Model POE (Predict Observe Explain) Untuk Melatihkan Keterampilan Proses IPA Siswa Sekolah Dasar. *Jurnal Basicedu*, *6*(1), 1232–1242. https://doi.org/10.31004/basicedu.v6i1.2267

Roudloh, D. M., Laili, D. H., Zahro, E. A. L., & Mulyanti, S. (2023). Review Literatur Perangkat Pembelajaran Kimia Pada Materi Hidrokarbon. *Prosiding Seminar Nasional Orientasi Pendidik Dan Peneliti Sains Indonesia*, *1*, 123–130. http://publishing.oppsi.or.id/index.php/SN/article/view/17

Sudjana, N. (2009). *Penilaian Hasil Proses Belajar Mengajar*. PT Remaja Rosdakarya.

Sumarni, W., Wijayati, N., & Supanti, S. (2019). Kemampuan Kognitif Dan Berpikir Kreatif Siswa Melalui Pembelajaran Berbasis Proyek Berpendekatan STEM. *Jurnal Pembelajaran Kimia OJS*, *4*(1), 18–30.

https://doi.org/https://doi.org/10.23887/jjpk.v3i1.21156

Suwarto. (2013). *Pengembangan Tes Diagnostik dalam Pembelajaran*. Pustaka Pelajar.

Taher, T. (2022). Deskripsi Pemahaman Konsep Mahasiswa pada Materi Hidrokarbon. *Jurnal Ilmiah Wahana Pendidikan*, *8*(21), 656–660. https://doi.org/https://doi.org/10.5281/zenodo.7558597

Tahir, N. N., Ismail, S., Oroh, F. A., Zakaria, P., & Usman, K. (2022). Analisis Kemampuan Pemahaman Konsep Matematika Ditinjau dari Penggunaan Multimedia Game Petualangan dalam limas berbasis Mobile Learning Di SMP Negeri 1 Tilango. *EULER: Jurnal Ilmiah Matematika, Sains Dan Teknologi*, *10*(1), 15–25. https://doi.org/https://doi.org/10.34312/euler.v10i1.12936

Triana, B. M. (2023). Potret Miskonsepsi Siswa SMA pada Materi Komponen Penyusun dan Interaksi dalam Ekosistem. *Jurnal Bioeduin*, *13*(2), 49–57. https://doi.org/https://doi.org/10.15575/bioeduin.v13i2.18766

Yulianto, R. E. (2020). Pendidikan Seni untuk Membentuk Manusia Ideal pada Sekolah Umum. *Imajinasi: Jurnal Seni*, *14*(1), 17–24. https://doi.org/https://doi.org/10.15294/imajinasi.v14i1.27685

Zandroto, A. V., & Sinaga, K. (2022). AnalisisKemampuan Literasi Kimia Siswa Pada Materi Senyawa Hidrokarbon Melalui Pendekatan Kontekstual. *Jurnal Pendidikan MIPA*, *12*(2), 349–358. https://doi.org/https://doi.org/10.37630/jpm.v12i2.596