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Description of Students' Multirepresentation Ability on Hydrocarbon Material at SMA Negeri 1 Sungai Kunyit

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Abstract: Material in chemistry learning will be easier to understand if students are able to represent it at three levels of representation, namely macroscopic, sub-microscopic and symbolic. This research aims to describe students' abilities in using various representations in class XI MIPA 1 hydrocarbon material at SMA Negeri 1 Sungai Kunyit. Students' thinking processes require various representations and various ways or steps to solve problems. The type of research used is quantitative descriptive research. The research instruments used included 9 two tier multiple choice objective test questions and an interview guide. This research involved 20 students of class XI MIPA 1 SMA Negeri 1 Sungai Kunyit. The research results show that overall, the average multi-representation ability of students is 29% in the poor category. At the macroscopic representation level, the average percentage obtained is 20% which can be classified as very poor. At the sub-microscopic level of representation, the average is 35% which is included in the poor category. Finally, at the level of symbolic representation the average percentage is 31% which is also included in the poor category.

Keywords: Ability; Hydrocarbons; Multirepresentation

Introduction

Chemistry lessons involve material consisting of concepts and calculations. It is often thought that chemistry is an abstract material and requires a deep understanding of concepts to study it. As a result, many students consider chemistry a difficult subject to study (Putri et al., 2019). According to Talanquer (2011), students face difficulties because they are unable to understand and apply three levels of multi-representation in explaining chemical concepts. In understanding chemistry there are three levels of chemical representation, namely macroscopic, sub-microscopic and symbolic which must be understood by students (Hasanah et al., 2024). Considering students' ability to describe chemistry through these three representations has an important role in increasing students' understanding. Therefore, it is important to observe students' ability to use various forms of representation so that they can understand chemical concepts well and develop scientific thinking skills (Rahmawati et al., 2021; Sim & Daniel, 2014).

To understand chemical material, three relevant representations are needed. The first is a macroscopic representation that can be observed directly in everyday life. Both submacroscopic or molecular representations are used to provide explanations at the particulate level. The three symbolic representations or icons are used to express statements using chemical symbols, formulas or equations, and molecular structures. These three representations help each other in understanding chemical concepts holistically (Fromm et al., 2021). Multirepresentation is an important ability for students to have. This factor occurs because students' understanding of abstract chemical material is very dependent on students' ability to master various levels of representation, as well as students' ability to transfer and connect between these levels of representation

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(Chandrasegaran et al., 2007). According to Adadan (2013), if students are able to represent three levels of representation of chemistry, it will be easier to understand. Student success in learning chemistry can be achieved when students use problem-solving skills using three levels of chemical representation (Farida et al., 2017). This is in accordance with research Widianingtiyas et al. (2015) namely the multi-representation approach has a positive effect on students' cognitive abilities.

According to Doyan et al. (2018), multirepresentation has three main functions, namely complementarity, interpretation and development of understanding. Then obey Bahaudin et al. (2019), multirepresentation as a complement in the form of information and processes, as a barrier to reduce the risk of misinterpretation between representations and as a builder of deeper understanding of learning topics or problem situations. So, the reason why multiple representations are important is because the structure of chemical knowledge requires various representations (multiple representations) so that it can be understood better. According to Mujibaturrahmi et al. (2022), one of the chemistry topics that includes all three levels of representation, namely macroscopic, sub-microscopic and symbolic, is hydrocarbon material. The macroscopic representation in question is hydrocarbon compounds in everyday life. The sub-microscopic representation in question is a molecule that is part of a hydrocarbon compound. The symbolic representation in question is the structural name of the hydrocarbon compound.

Hydrocarbon material is a basic concept that covers several topics, including classification of hydrocarbon compounds, compound nomenclature, isomers, and reactions of hydrocarbon compounds (Nukila et al., 2022). Generally, students have difficulty discussing the concept of nomenclature and reactions that occur in each hydrocarbon compound. Students are also unable to explain what happens at the level of hydrocarbon compounds (Eky et al., 2018). The use of monotonous learning methods such as lectures and discussions cause students to consider chemistry material to be difficult and abstract. The application of the lecture method in learning causes a lack of student involvement in the learning process which causes low retention of information obtained by students so that it can have a negative effect on student learning outcomes (Tomlinson et al., 2023; Nadeem et al., 2023). So, to increase student activity so that they do not feel bored and bored during learning, variations in learning need to be made.

Based on the results of an interview with one of the chemistry subject teachers at SMA Negeri 1 Sungai Kunyit class XI MIPA on Thursday, December 22 2022, the lecture method is often chosen by teachers in learning because of its ease of application to students. Apart from that, practicums are never carried out by teachers in the learning process. Then students experience difficulties in hydrocarbon material, namely how to determine the nomenclature of compounds, starting from numbering the carbon chain, determining the main chain, and determining branches, then students also have difficulty describing the structure of hydrocarbon compounds, besides that students also experience difficulty in understanding the reaction process involved. occurs in hydrocarbon compounds. The difficulties experienced by students are because students only focus on the example questions given by the teacher, but when they are given new and varied questions, students start to get confused because they don't understand the chemistry concept or only memorize the theory.

Based on the statement above, the aim of this research is to describe students' abilities in using various representations in class XI MIPA 1 hydrocarbon material at SMA Negeri 1 Sungai Kunyit, with the hope of providing information regarding students' multi-representational abilities.

Method

The research method used is quantitative descriptive research. The subjects in this research were 20 students in class XI MIPA 1 at SMA Negeri 1 Sungai Kunyit. To obtain data regarding students' multiple representation abilities, the instruments used were test questions and interview guidelines. The test questions used in this research are a two tier multiple choice objective test totaling 9 questions, where in this research the test questions represent every aspect of representation, namely macroscopic, sub-microscopic and symbolic. The interview guide used was a free guided interview.

The data collected is then analyzed by correcting the questions and giving scores to students' answers according to the established scoring guidelines. Next, the percentage of students' multiple representation abilities at each level of representation is calculated using the formula:

$$\%\ \text{Ability} = \frac{\text{Total student scores}}{\text{Maximum score}} \times 100 \quad (1)$$

The next step is to calculate the average total student score on hydrocarbon material for each aspect of representation, namely macroscopic, sub-microscopic and symbolic. Next, identification of the ability categories in each representation is carried out based on the score calculations that have been carried out. This ability category refers to the scale proposed by Kyriazos et al. (2018) and Kutscher et al. (2020) can be seen in Table 1.

Table 1. Ability Categories

Percentage Range (%)	Ability Category
81-100	Very good
61-80	Good
41-60	Enough
21-40	Not enough
< 20	Very less

The final step is to analyze the interview transcript to obtain additional information that is not included in filling out the test questions and make conclusions regarding students' multiple representations in each aspect of representation.

Result and Discussion

This research was carried out at SMA Negeri 1 Sungai Kunyit on class to describe students' multiple representation abilities in hydrocarbon material. The test question instruments and interview guidelines that have been prepared previously have undergone a content validity process by a team of experts consisting of 1 UNTAN Chemistry Education lecturer and 2 Chemistry teachers at SMA Negeri 1 Sungai Kunyit. The validation used uses the Aiken technique. After receiving advice from the expert team, the instrument has been improved so that the test questions have a validity value of 0.850 which indicates a very high validity category. Likewise, the interview guide obtained a validity value of 0.858, which was also categorized as very high. After obtaining the validity of the expert team, the test question instrument was then tested to measure the reliability of the questions on 19 students of class XI MIPA 2. The reliability testing technique used the KR 20 formula. consistent so that it is suitable for use as a research instrument.

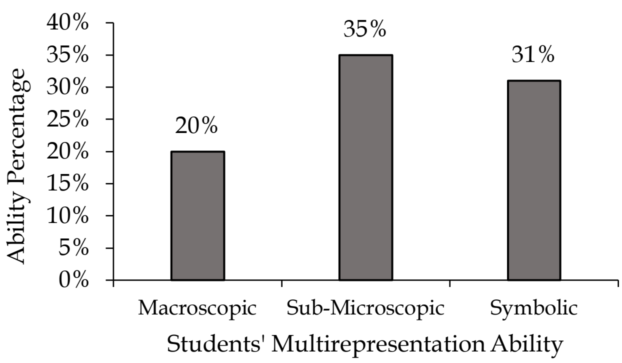


Figure 1. Students' multiple representation abilities

Data from students' two tier multiple choice objective test results were grouped into three representational abilities, namely macroscopic, sub-microscopic and symbolic, so that the results obtained were in accordance with Figure 1. Figure 1 shows that students' ability to use multiple representations in hydrocarbon material at the macroscopic representation level shows a very low level, with a percentage of 20%. Furthermore, students who have a deficient category are at the sub-microscopic and symbolic levels with percentages of 35% and 31% respectively.

Thus, overall, the average ability of students in using multiple representations in hydrocarbon material can be categorized as very poor, with a percentage of 29%. This is influenced by students not being able to properly understand the material on hydrocarbon compounds, so students have difficulty representing phenomena at the macroscopic, sub-microscopic and symbolic levels. Based on the interview results, almost all students felt that chemistry material was difficult. According to Sokrat et al. (2014) and Ali (2012), students' difficulties in learning chemistry are generally caused by students' low understanding of concepts. This results in difficulties for students in understanding the concepts being taught. Meanwhile, according to Handayani et al. (2018), chemistry learning that contains all three levels of representation will make students' understanding of chemistry complete. So, students need to develop their multiple representation abilities.

Based on this research, it was found that students' macroscopic representation abilities were very low when compared to other levels of representation. This is similar to research conducted by Zahro' et al. (2021) to class XI Science students at SMA Negeri 1 Krian regarding Chemical Equilibrium material. The research also shows that students' abilities at the macroscopic representation level are significantly lower compared to sub-microscopic and symbolic representations said that teachers often train macroscopic representation skills through practical activities in the laboratory. This is in line with the results of research conducted by Colletti et al. (2023) which shows that macroscopic questions discuss questions about real or fictitious experiences related to students' daily experiences that can be observed through the five senses. Then obey Macroscopic representation abilities are usually trained by carrying out observation activities around the environment or through practicums carried out in the laboratory. Meanwhile, based on interviews during the lesson, the teacher did not do any practical work in the laboratory, this is one of the factors in the students' very poor macroscopic representation abilities.

Sub-microscopic representation is the level where students use the knowledge, they gain through the learning process to understand abstract chemical concepts. According to Eliyawati et al. (2018), students' understanding of macroscopic representations has an influence on their ability to understand sub-microscopic concepts. As a result, students' ability to understand sub-microscopic concepts tends to be relatively poor. The results of interviews with students show that they have difficulty understanding the processes that occur at the sub-microscopic level due to the lack of visualization in learning that only relies on verbal. Meanwhile, according to Bobek et al. (2016), sub-microscopic representations are difficult to understand if they are only presented with explanations without any visualization with two-way interactive explanations. The sub-microscopic level students find it difficult because this aspect is not visible while students' minds rely on sensory-motor information experienced by their five senses. The use of visualization such as video, animation, and augmented reality can play an important role in representing submicroscopic phenomena. Through the use of visual aids, it can help to illustrate submicroscopic concepts more clearly and realistically for students (Wulandari et al., 2019).

Symbolic representation is a level of chemistry in the form of symbols such as the chemical formula of a compound, structural images, reaction equations, mathematical equations, and reaction mechanisms. According to Susac et al. (2014), chemistry more often uses mathematical symbols, formulas and equations. Mastering the symbolic level should be easier for students. However, the data obtained showed that students' symbolic representation abilities were classified as poor, different from the results of previous research conducted by Hohol et al. (2020) on Reaction Rate material. This research shows that students' abilities in symbolic representation reached a percentage of 70.57% in the good category. Based on the results of interviews, students stated that they had difficulty differentiating the formulas of hydrocarbon compounds which looked almost the same, then students had difficulty understanding the correct naming rules and applying them to the given hydrocarbon compounds. This is because students' understanding of the concept of hydrocarbon compounds is not yet good.

Macroscopic Level Multirepresentation Capabilities

Figure 2 shows students' macroscopic representation abilities in hydrocarbon compound material. Based on Figure 2, it shows that questions number 1 and 2 received the very poor category with percentage values of 5% and 10% respectively. Meanwhile, question number 3 is classified as sufficient with a percentage of 45%. Thus, the macroscopic representation ability can be categorized as very poor with an average percentage value of 20%. According to theory, the macroscopic level is real. Observed phenomena can include the appearance of aromas, color changes, formation of gases and precipitates in chemical processes. According to Based on Figure 2, it shows that questions number 1 and 2 received the very poor category with percentage values of 5% and 10% respectively. Meanwhile, question number 3 is classified as sufficient with a percentage of 45%. Thus, the macroscopic representation ability can be categorized as very poor with an average percentage value of 20%. According to theory, the macroscopic level is real. Observed phenomena can include the appearance of aromas, color changes, formation of gases and precipitates in chemical processes. According to Wiyarsi et al. (2018), macroscopic representations describe phenomena based on life experience or experiments, where everything can be seen, touched and felt.

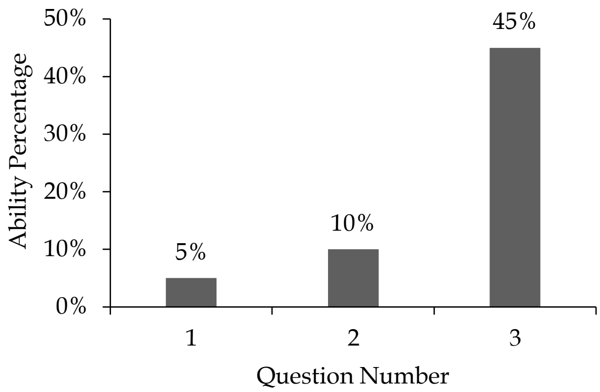
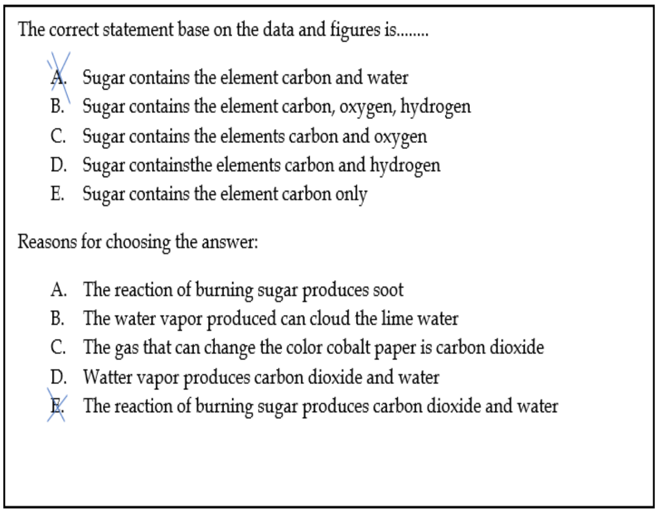


Figure 2. Macroscopic representation capabilities

Question number 1 in the macroscopic representation has an indicator that students can determine the reaction that occurs between alkene compounds and bromine. In this question, students got a very poor category and it was the lowest score compared to other macroscopic representation questions. Almost all students answered this question incorrectly, because students had difficulty answering question number 1. Based on the results of the interview, students felt confused about the process that occurred in question number 1. One aspect that made it difficult for students was the change in color of the bromine solution when it reacted with alkene compounds. Apart from that, students also do not understand the reactions that occur in hydrocarbon compounds, which causes students to answer question number 1 incorrectly.

According to Sulastri et al. (2018), in theory, an addition reaction occurs when the double bond in an alkene compound is lost due to the addition of another substance. In this problem, when the bromine solution which was originally red-brown in color was mixed with an alkene compound, the color of the bromine solution changed to colorless. This change occurs due to the formation of colorless dibromide compounds. Students' ability in macroscopic representation for question number 2 has an indicator that students can conclude the experimental data presented. In this question, students received a very poor category. Based on the results of interviews with students, they expressed difficulty in answering question number 2 because they did not understand the experimental data presented. Then it can be seen from the answers of other students that they know the results of the combustion reaction to produce carbon dioxide and water. In this case, it can be seen from the students' correct answers when choosing the reason in question number 2, but they were wrong in answering the main question, which can be seen in Figure 3.


The correct statement base on the data and figures is........

A. Sugar contains the element carbon and water
B. Sugar contains the element carbon, oxygen, hydrogen
C. Sugar contains the elements carbon and oxygen
D. Sugar containsthe elements carbon and hydrogen
E. Sugar contains the element carbon only

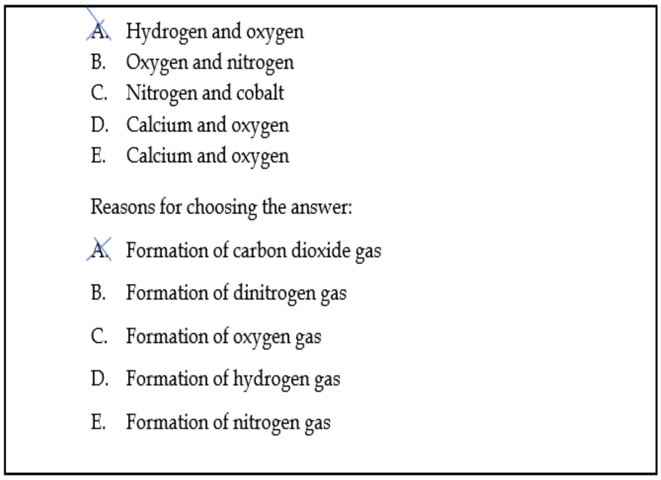
Reasons for choosing the answer:

A. The reaction of burning sugar produces soot
B. The water vapor produced can cloud the lime water
C. The gas that can change the color cobalt paper is carbon dioxide
D. Watter vapor produces carbon dioxide and water
E. The reaction of burning sugar produces carbon dioxide and water

Figure 3. Student answer number 2

When sugar is heated or burned it will produce carbon dioxide gas (CO_2) and water vapor (H_2O), so the elements contained in sugar are the elements C, H, and O. If you look at the 2 statements presented in question number 2, the first statement is gas resulting can cloud the lime water. The lime water becomes cloudy, proving that the gas is carbon dioxide gas or CO_2 which, if mixed with $Ca(OH)_2$ lime water, will produce $CaCO_3$ deposits which will cause the lime water to become cloudy, which means that sugar contains elements C and elements O. Then the second statement is gas. The resulting color changes the color of the cobalt paper from blue to pink. Kohse-Höinghaus (2023) stated that the color change of cobalt blue paper to pink caused by the gas produced when burning sugar could be explained by the presence of water vapor or H_2O. This indicates the presence of H elements and O elements.

Question number 3 shows students' ability in macroscopic representation with the question category students can determine the results of combustion of hydrocarbon compounds. In this question, students get the sufficient category. According to the interview results, students considered question number 3 difficult because they did not understand the process that occurred in the hydrocarbon compound test presented, namely why the lime water could become cloudy. Then there are also students' answers who know that the results of the combustion reaction produce carbon dioxide and water. This can be seen from the students' correct answers when choosing the reason in question number 3, but they were wrong in answering the main question, which can be seen in Figure 4.


A. Hydrogen and oxygen
B. Oxygen and nitrogen
C. Nitrogen and cobalt
D. Calcium and oxygen
E. Calcium and oxygen

Reasons for choosing the answer:

A. Formation of carbon dioxide gas
B. Formation of dinitrogen gas
C. Formation of oxygen gas
D. Formation of hydrogen gas
E. Formation of nitrogen gas

Figure 4. Student answer number 3

In theory, in complete combustion, the products produced are carbon dioxide gas (CO_2) and water vapor (H_2O). Testing for the presence of CO_2 can be carried out by heating carbon compounds in a closed system, where the resulting gas is flowed into a lime water solution ($Ca(OH)_2$). If CO_2 gas is produced, the solution will turn cloudy due to the formation of lime ($CaCO_3$).

Sub-Microscopic Leverl Multirepresentation Capabilities

Figure 5 shows students' sub-microscopic representation abilities in hydrocarbon compound material. Based on Figure 5, it shows that question number 4 received a very poor category with a percentage value of 20%. Meanwhile, question number 5 is classified as poor with a percentage value of 25% and question number 6 is categorized as sufficient with a percentage value of 60%. As a result, overall students' sub-microscopic representation abilities are classified as poor with an average percentage score of 35%. According to Hikmayanti et al. (2019), at the sub-microscopic level of representation, students apply knowledge from their learning experiences to understand abstract concepts.

So sub-microscopic is defined as the level of representation at which the behavior of substances is interpreted in an invisible and molecular context.

Question number 4 in sub-microscopic representation has an indicator that students can analyze the type of perfect combustion reaction. In this question, students got a very poor category and it was the lowest score compared to other sub-microscopic representation questions. The concept of hydrocarbon combustion reactions is included in the abstract concept category. Based on the results of interviews, students find it difficult to visualize and understand this concept because they cannot directly see the reactions that occur, so students answer question number 4 incorrectly. Abstract concepts often require higher thinking and reasoning, which can be a challenge for some students.

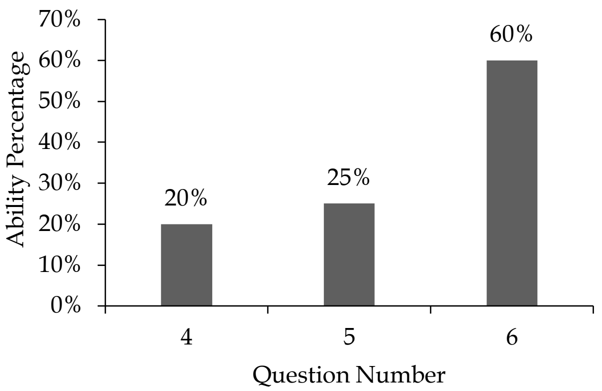


Figure 5. Sub-microscopic representation capabilities

Question number 5 shows students' ability in sub-microscopic representation. It has an indicator that students can determine the hydrocarbon compounds present in clothing. In this question, students get the poor category. Based on the results of interviews, students find it difficult to visualize alkene compounds because students do not understand the characteristics of alkene compounds because their chemical formula looks almost the same as alkanes. This difficulty exists because students tend to rely on memorization and only remember theory without really understanding the material well. Alkenes have the general formula C_nH_{2n} and have a double bond C=C.

Students' ability in sub-microscopic representation in question number 6 has an indicator that students can determine alkane group compounds from the names of the compounds given. In this question, students get the sufficient category. Based on the results of the interview, students had difficulty working on the questions because they felt confused in determining the name of the longest chain and branch chain. Apart from that, students have difficulty with the nomenclature system so they cannot correctly identify alkane group compounds. The reason is because students tend to only rely on rote memorization to remember the theory of how to name hydrocarbon compounds, but they find it difficult to apply this knowledge in naming hydrocarbon compounds (Purwanto, 2021).

Symbolic Level Multirepresentation Ability

Figure 6 shows students' symbolic representation abilities in hydrocarbon compound material, as follows. Based on Figure 6, it shows that question number 7 is in the poor category with a percentage value of 23%. Meanwhile, question number 8 is classified as sufficient with a percentage value of 52% and question number 6 is in the very poor category with a percentage value of 17%. Thus, overall students' symbolic representation abilities are classified as poor with an average percentage score of 31%. According to symbolic representation theory, it is a representation that involves the use of symbols, formulas and chemical equations (Ott et al., 2018). So, symbolic representation is the level of chemistry in the form of symbols such as the chemical formula of a compound, structural images, reaction equations, mathematical equations, and reaction mechanisms.

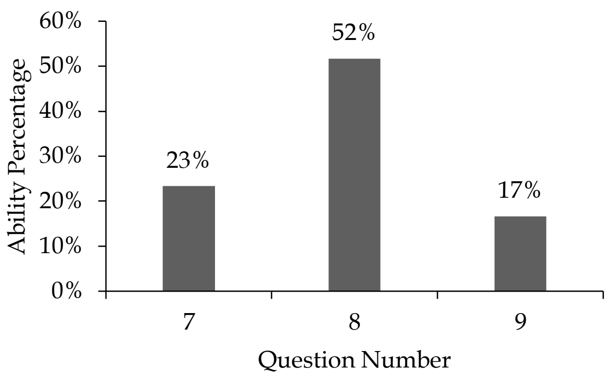
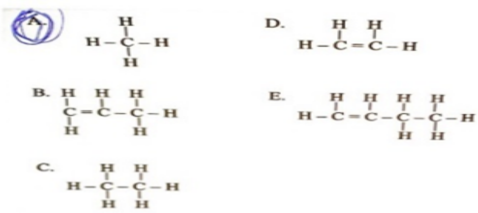


Figure 6. Symbolic representation capabilities

Students' ability to symbolically represent question number 7 has an indicator that students can determine the structure of alkene compounds. In this question, students get the poor category. Students are asked to determine alkene compounds. Based on the results of the interview, students found it difficult to work on question number 7 because they did not know the general formula for compounds. Then it can also be seen from the students' answers that on average they know the general formula that alkenes have, but students have difficulty visualizing the structure of alkenes. This can be seen from the students' correct answers when choosing the reason in question number 7, but they were wrong in answering the main question, can be seen in Figure 7. Alkenes have the general formula C_nH_{2n} and have a double bond C=C.

Question number 8 has an indicator that students can determine the structure of hydrocarbon compounds, namely distinguishing primary C atoms. In this question, students get the sufficient category. Based on the results of the interview, students felt that question number 8 was difficult because students could not distinguish which C atom was primary. Then it can be seen from the students' answers that on average they were correct when choosing the main question number 2, but they were wrong in choosing the reason, which can be seen in Figure 8.



Reasons for choosing an answer:
A. Alkene compounds have the general formula C_nH_{2n+1}
B. Alkene compounds have the general formula C_nH_{2n-2}
C. Alkene compounds have the general formula C_nH_{2n}
D. Alkene compounds have the formula C_nH_{2n+2}
E. Alkene compounds have the general formula $C_{n-2}H_{2n}$

Figure 7. Student answer number 7

Students have the view that the primary C atom is an atom that is bonded to one CH_3. However, the actual answer fits the theory the primary C atom is the atom that binds 1 neighboring C atom in 1 carbon chain. Apart from that, there are still students who are confused about distinguishing between primary, secondary and tertiary C atoms. According to Derman et al. (2019), the errors that occur are likely caused by students' lack of understanding of the concept of type C atoms in depth. Apart from that, learning methods that rely solely on memorization also have the potential to cause students to misunderstand the differences between primary, secondary, tertiary and quaternary C atoms (Lazou & Tsinakos, 2023; Radmehr & Drake, 2020).

A. 1, 3, 6, 7,8, and 9
B. 1, 6, 7,8, 9, and 10
C. 1, 2, 3, 7, 8, and 10
D. 1, 4, 5, 6, 7, and 9
E. 1, 2, 4, 5, 6, and 9
Reasons for choosing the answer:
A. The primary C atom binds one C atom
B. The primary C atom binds CH3
C. The primary C atom binds four C atoms
D. The primary C atom binds one H atom
E. The primary C atom binds CH4

Figure 8. Student answer number 8

Next, in question number 9, students are asked to determine the name of the structure of the alkene compound presented. The correct way to name alkene compounds is to identify the longest carbon chain through a double bond and numbering for the C atom is done by placing the double bond at the smallest number (Rahmawati et al., 2018). In question number 9, almost all students answered the question incorrectly. Based on interviews, students were confused about naming the longest chain and branch chain. Then it can be seen from the average student answers that they are wrong in determining the longest chain as the main chain, it can be seen from the students' answers which can be seen in Figure 9 where students assume that the longest chain is only 6.

A. 2,5-dimethyl-2-heptene
B. 5-ethyl, 2-methyl-2-hexene
C. 3,6 dimethyl 5 heptene
D. 2-methyl, 5-ethyl-2-hexene
E. 3,6 diethyl-2-hexene
Reasons for choosing the answer:
A. Determine the straight chain, passing through the double bonds and given the number closest to the double bond
B. Determine the longest chain that passes through the double bond and number the nearest double bond, in alphabetical order
C. Determine the longest chain and cross the double bond, the numbering does not have to be close to the double
D. Determine the straight chain and pass through the bonds and give the number closest to the double bond, naming according to the smallest number
E. Determine the straight chain, pass through the bonds and give the number closest to the double bond and give the smallest number to the double bond

Figure 9. Student answer number 9

The difficulties experienced by students are caused by the tendency to rely on rote memorization by remembering the theory of how to name hydrocarbon compounds, but they find it difficult to apply this knowledge in naming the hydrocarbon compounds given (Chiu et al., 2019). Apart from that, students' ability to recognize and understand questions that are different from the examples given by the teacher is low. This causes students to be unable to answer questions correctly.

Conclusion

Based on the results of data analysis that has been carried out on the multi-representation abilities in hydrocarbon material of class. The multi-representation capability at the macroscopic level is 20%, the sub-microscopic level is 35%, and the symbolic level is 31%. In the learning process, teachers should place more emphasis on each representation, including macroscopic, sub-microscopic and symbolic representations. So, it is recommended to use various media or teaching materials that can integrate the three levels of student representation proportionally.

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Author Contributions
Creating research instruments, carrying out research, and writing reviews of research articles, writer A. H. Guiding the research and article writing process, writers H. and U. M. Writer E. analyzing the writing, review, and validation of instruments. Author L. I analyze the writing and review.

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The authors declare no conflict of interest.

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