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Identification of Student Conceptions on the Molecular Structure of Organic Compounds Using Question

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Abstract
The atoms that make up organic molecules are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), sulfur (S), and several other elements such as chlorine (Cl), bromine (Br), and iodine (I). The characteristics of the constituent organic molecules are important to study in order to understand the reactions and transformations in the synthesis of organic compounds. The weak conception of students about the characteristics of the constituent elements of organic compounds causes most students to experience difficulties in studying the structure of organic compounds. The purpose of this study was to find out the strengths and weaknesses of students' conceptions in understanding the molecular structure of organic compounds. This research is a quantitative descriptive research. The population of the study was 20 chemistry education students taking the basics of determining the structure of organic compounds. Samples were selected proportionally to the most. The instrument used is a description test designed in the form of a question mapping. The data obtained is then described in tables and graphs. The results showed that most of them were able to determine the types of atoms and bonds formed. Most students have not been able to explain the characteristics of the atoms that make up organic compounds and the subatomic characters that make up the atoms. Technology is needed that can visualize organic molecules at the atomic and subatomic levels to be able to build stronger student conceptions.

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INTRODUCTION

Concept maps are visual tools used to organize and link related ideas, concepts or information. This helps in understanding the relationship between these concepts and helps visualize the structure or series of information (Alt Dorit., 2021; Amin et al., 2020; Aritia and Suyanto., 2019; Mento et al., 1988). The main thing in a concept map is to determine the main concept that will be reduced to smaller sub-concepts. This approach can also be used by turning the main concept into a core question. Questions made in a well-organized question map can foster conceptual understanding and higher-order thinking skills (Habiddin & Page, 2020). Question mapping is a question that is composed of core problems in an arranged learning context to find answers to a series of problems that are arranged in stages (Desmarais., 2012).

The power of questions lies in their ability to evoke thought, reflection, and the search for new knowledge. Good questions can open discussions, explore new ideas, bring up different points of view, and encourage critical thinking (Abduljabbar & Omar, 2015; Gillette and Sanger., 2018; Lusiana, 2021). Thought provoking, challenging questions can force people to consider new points of view or see problems from a different perspective. It helps develop critical thinking and creativity (Cook et al., 2020; Habiddin & Page, 2020; Hamid, 2018). Accurate questions can encourage self-reflection. Questions can force a person to reflect on their own values, beliefs, or actions. It helps in personal development and self-understanding. Conferential questions can dig up new knowledge, questions can direct someone to look for information that they did not know before. It aids in learning and intellectual growth (Brooks & John, 2018; Cook et al., 2020).

Relevant, contextual and targeted questions can help identify root causes and find effective solutions (Brooks & John, 2018; Habiddin & Page, 2020). The power of questions lies in their ability to stimulate thought, generate new insights, and pave the way for deeper understanding. By asking the right questions, we can achieve better understanding, increase collaboration, and reach better solutions. Questions aimed at checking understanding can help reinforce knowledge and ensure that information has been understood correctly. These kinds of questions can also help identify areas that need clarification or further study. Understanding abstract chemistry requires critical thinking.

Abstract chemical material causes students difficulties in understanding it (Gilewski et al., 2022; Harza et al., 2021). Multiple representations are needed in building a more complete chemical concept. (Alam, 2020) states that computational skills and contextual knowledge are needed in building meaningful knowledge. The separation of macroscopic, microscopic and symbolic concept levels can lead to incomplete understanding. Chemistry studies the character, properties, composition of the atomic, molecular and macromolecular levels. If the concept foundation at the atomic level is weak it can lead to weak understanding of the concept at the molecular and macromolecular level.

Organic molecules are molecules that are composed of the element carbon and usually also contain the element hydrogen. Organic molecules can be found in many forms, from simple compounds such as methane (CH_4) to complex compounds such as proteins, carbohydrates and fats. Elemental carbon is a very important element in organic molecules because it has the ability to form covalent bonds with other atoms, including carbon itself. Carbon is the main chain of organic compounds (Champagne et al., 2015; Sabzehmeidani et al., 2021). This allows the formation of long and complex branched carbon chains, forming the basic framework of organic molecules. Organic molecules can be found in nature in various forms, including in plants, animals, microorganisms, and other natural resources (Su et al., 2021; Zhang et al., 2021). They can also be synthesized in a laboratory in certain chemical reactions. The study of organic molecules cannot be separated from the study of the characteristics of their constituent atoms, which have implications for the various differences in the physicochemical characteristics of the molecules.

The atoms that make up molecules and organic compounds have several important characteristics. The atoms that make up organic molecules are carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), sulfur (S), and several other elements such as chlorine (Cl), bromine (Br), and iodine (I). Carbon is the most characteristic element in organic compounds because it has the ability to form strong covalent bonds with other atoms (Gyamfi et al., 2019; Sun et al., 2012). The carbon atom has four valence electrons, so it can form bonds with four other atoms. Hydrogen has only one valence electron, oxygen and nitrogen have two valence electrons, and several other elements have different valences (Lin et al., 2019).

The atoms that make up organic molecules are held together by covalent bonds, in which the valence electrons are shared between the atoms. A covalent bond can form between two atoms (single bond), between two atoms by sharing two pairs of electrons (a double bond), or between several atoms (a double bond or a triple bond). Carbon has the ability to form long and branched chains, so organic molecules can have complex structures. Carbon chains can form bonds with other atoms or form aromatic rings (Sabzehmeidani et al., 2021). The covalent bonds in organic molecules are generally quite strong, giving the molecule stability. However, covalent bonds can also be broken through certain chemical reactions. Functional groups are groups of atoms attached to the carbon chain in organic molecules. Functional groups provide unique chemical properties to organic compounds and can affect their reactivity and physical properties (Chen et al., 2015; Held et al., 2017). Organic compounds often have isomers, that is, compounds with the same molecular formula but different structures and properties. Isomerism can occur due to differences in the arrangement of atoms or the arrangement of bonds in molecules (Karmakar et al., 2017).

Organic compounds tend to have high reactivity because the constituent atoms have completely unbound valence electrons. Organic molecules can undergo various types of chemical reactions, such as substitution, elimination, or addition, which allow new compounds to form. These characteristics help explain the distinctive properties of organic compounds and play an important role in organic chemistry as well as in various applications and interactions with living things and the environment (Atar et al., 2019; Sun et al., 2012; Zeng et al. , 2015, 2021). The characteristics of organic molecules are so complex. The level of organic chemistry material causes chemistry education students to experience difficulties in building a comprehensive understanding. Question maps with problem-based learning are a technique for mapping students' abilities to understand the molecular structure of organic compounds. This research is important to do because the application of question maps (question mapping) is still rarely done to explore student understanding.

Question mapping is the process of connecting the questions posed by users with relevant answers or information. The process of question mapping involves analysis and understanding of user questions. Question text is broken up into smaller parts, such as words or phrases. This is done to describe the extent to which students have mastered the material they have studied. Question mapping helps lecturers find student strengths and weaknesses in understanding chemical concepts. Question mapping is able to provide an overview of students' thinking abilities so that lecturers are able to design learning that is more effective in presenting more meaningful and effective learning in growing and improving learning outcomes (Hulyadi, 2021) states that meaningful learning can be presented through selecting relevant and contextual problems with the problems arise around students.

Problems such as environmental issues and green energy are selected and adapted to the learning context. Environmental issues such as global warming are the impact that is felt today. (Johsson et al, 2019; Leggett & Ball, 2012) states that the current use of fossil fuels has a very pronounced impact on increasing earth temperatures and the occurrence of weather anomalies. The use of renewable and environmentally friendly energy is the most preferred solution in the world today. Students will not be able to provide solutions to environmental problems that we feel so real, if the lecturer does not present environmental issues related to the context of lecture material. Students who are responsive and creative towards problems are demands for an independent learning curriculum. So the use of Question mapping is important to map students' ability to understand the molecular structure of organic chemistry. Contextual issues related to environmental and energy issues are important to continue to study in order to create environmentally friendly energy.

METHOD

This research is a qualitative descriptive study. This type of research aims to describe and understand phenomena or events in detail and depth. This research focuses on a deeper understanding of the context of students' abilities in studying and analyzing the molecular structure of organic chemistry. This research was conducted on fourth semester students who were taking a course on determining the structure of organic compounds. The population in the study consisted of one class with 30 students. The sample in the study was selected by means of a porposive sample. Qualitative descriptive research uses qualitative methods, which means that researchers collect data in the form of words, narrations, pictures or sound recordings which are then analyzed in depth. The research focuses on students' ability to describe the questions built into the question mapping. Students' ability to interpret reasons and describe phenomena that become problems in learning is analyzed as an illustration of the level of student understanding. In this study, data analysis was carried out inductively, that is, researchers develop theories or findings based on collected data, not based on previous hypotheses (Doyle et al., 2020; Nilsson & Niedderer, 2014; Pratt & Yezierski, 2018). Figure 1 shows the question mapping given to students to explore students' conceptions of charges on organic molecules.

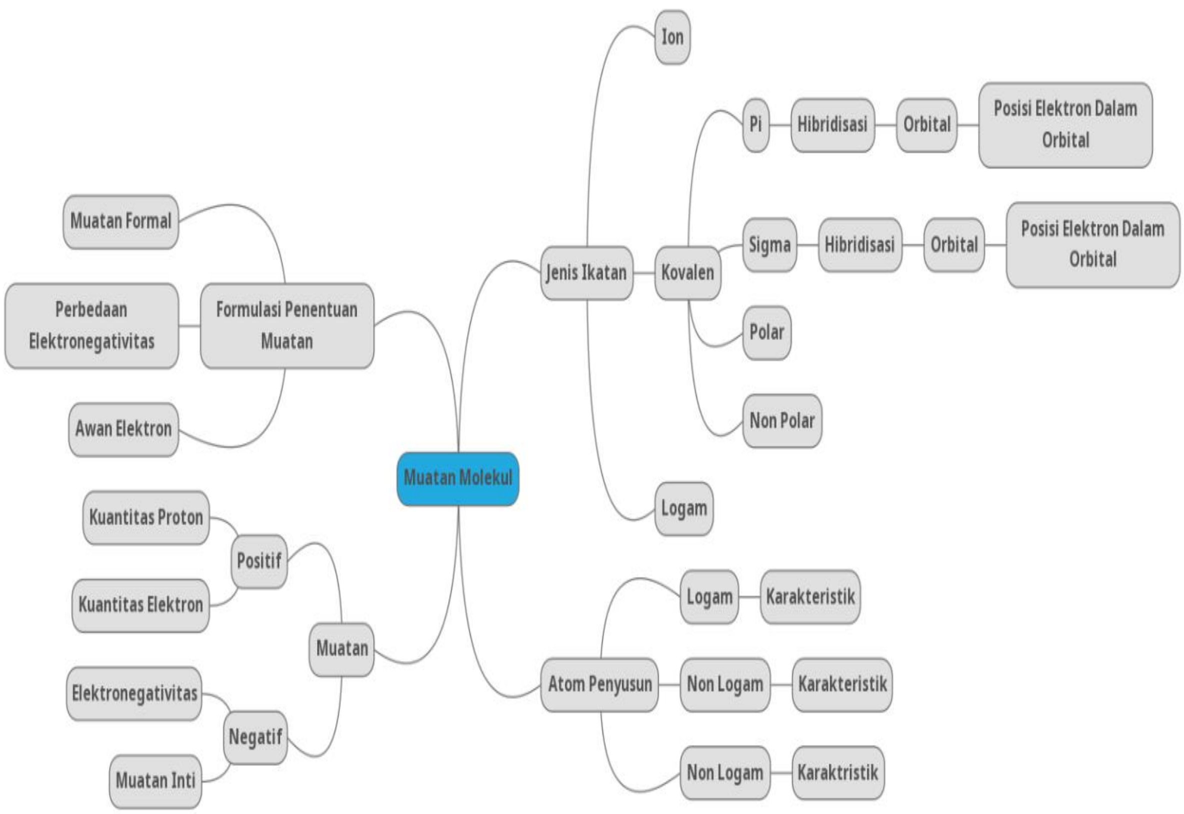

Figure 1 The Question Mapping Given to Students to Explore Students' Conceptions of Charges on Organic Molecules

RESULTS AND DISCUSSION

The research was conducted to find the weaknesses of students' conceptions in the in-depth study of organic molecules in the synthesis of biodiesel from used cooking oil. An in-depth study was carried out to build a complete conception of the characteristics of organic molecules. Strong and comprehensive conceptions can reduce misconceptions that occur in students when studying chemical concepts. The concept of chemistry which is built from the concept of atoms, subatoms that are bound into molecules and macromolecules is very difficult to understand because of the complexity of the material that must be studied. Atoms and molecules that make up abstract organic compounds add to the difficulties of students in understanding organic compounds. the use of question mapping is used by researchers to build and deepen understanding in students. Based on the research conducted on chemistry education students, it was found that most of them did not understand the molecular structure of organic chemistry at the basic concept level. Conceptual recapitulation of the study of organic molecular structure is shown in figure 2.

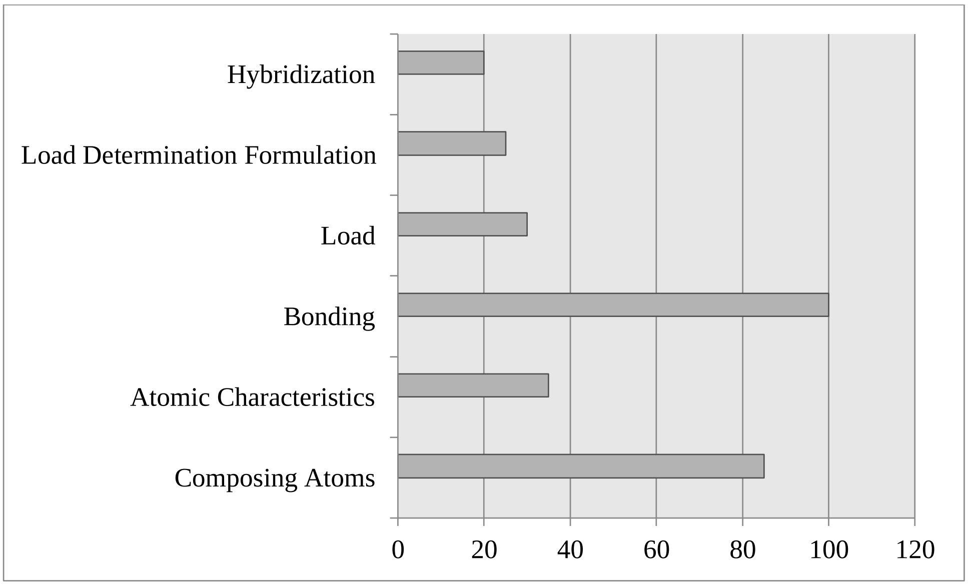

Figure 2. Conceptual Recapitulation of The Study of Organic Molecular Structure

The findings of the researchers showed that students were able to determine the type of bonds between atoms. In general, students still do not understand deeply and thoroughly the molecular structure of organic compounds. The study of the molecular structure of triglyceride organic compounds focuses on the carbonyl group which is the most dominant group in the transesterification reaction of used cooking oil (Awogbemi et al, 2019; Li et al., 2020; Muanruksa, 2020). Students are able to determine the constituent atoms but still have difficulty studying the characteristics of the constituent atoms. Atomic characteristics study the types of atoms, groups, valence electrons, subatomic particles, and electronegativity. The characteristics of the atoms that make up organic compounds are so complex that students are unable to fully understand them. New students are able to determine the type of atom, group, and valence electrons. Subatomic and electronegativity studies cannot be understood by students. Abstract subatomic material becomes difficult for students to study because it affects atomic characteristics. Models are needed that can visually describe atoms and their subatomic particles to facilitate students in the overall conception of atoms (Khaeruman et al., 2017; Perdana et al., 2020).

The lowest ability in studying the structure of triglyceride molecules is found in the concept of charge, formulation of charge determination, and hybridization. A small number of students are able to determine content using formal content formulations. Almost all students have not been able to determine the charge from the study of the subatomic constituents of the molecule. Students do not understand the number of protons and electrons of each atom before and after reacting in the transesterification reaction which causes the formation of a negative charge on the O atom. Figure 3 below shows that students have not been able to study the charge of their subatomic particles.

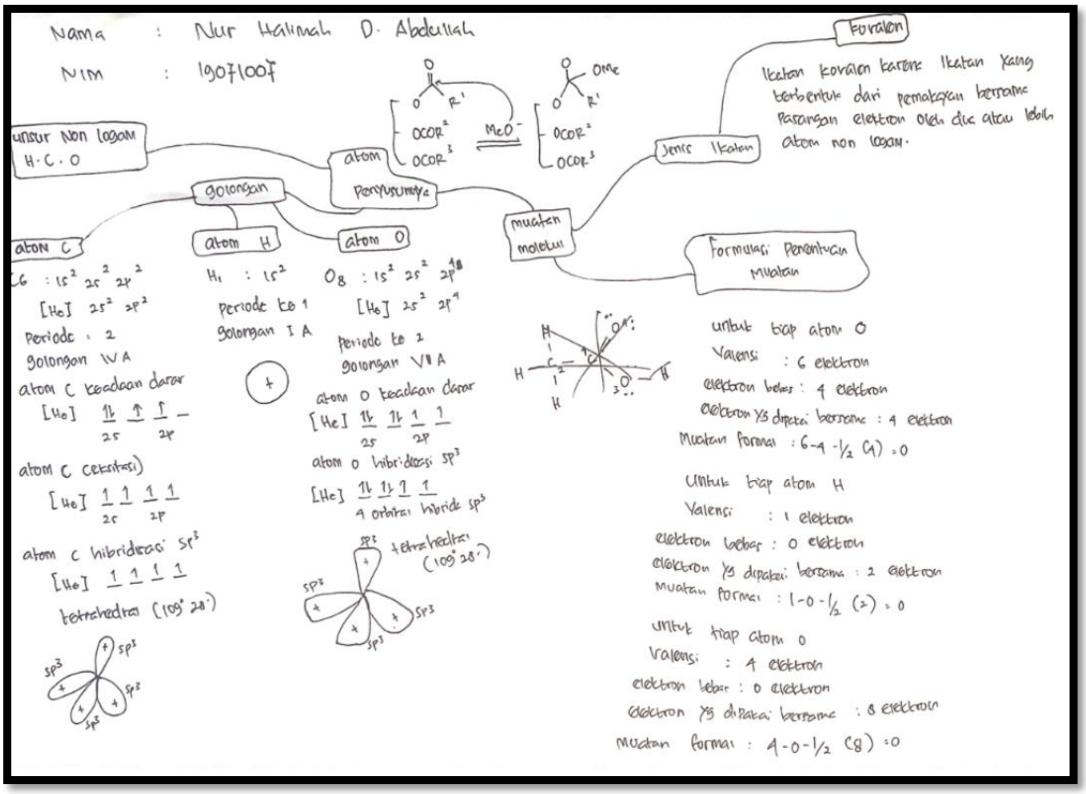

Figure 3. Picture Show the Students Weakness on Determine the Charge of Their Subatomic Particles

Question mapping is proven to be able to provide a comprehensive picture of student conceptions. The use of this technique is able to direct and guide students in building in-depth concepts (Amin et al., 2020; Brooks & John, 2018; Burrows & Mooring, 2015; Desmarais., 2012). Question mapping is also able to foster student curiosity as seen from the enthusiasm students ask questions. The element that is the main bond in organic compounds is carbon. Carbon has the ability to form long and branched chains, so organic molecules can have complex structures. The carbon chains can form bonds with other atoms or form aromatic rings. The covalent bonds in organic molecules are generally quite strong, giving the molecule stability. However, covalent bonds can also be broken through certain chemical reactions. More than one carbon bond tends to be more reactive than single bonds (Hearne et al., 2019; Jena et al., 2022). Carbon also has the ability to form double bonds with other elements such as oxygen, nitrogen and sulfur (Frenking et al., 2014; Jena et al., 2022).

The reactive group in an ordinary organic compound becomes its molecular identity. This group is known as a functional group. Functional groups are mostly formed from σ and π bonds between carbon and oxygen. Although carbon is the main bond but the presence of oxygen in organic compounds is very important as a strong electron donor and acceptor. This condition causes carbon and oxygen bonds to be transformed to form new compounds in organic compound synthesis reactions (Alabugin et al., 2021). Functional groups are groups of atoms attached to the carbon chain in organic molecules. Functional groups give organic compounds unique chemical properties and can affect their reactivity and physical properties. Organic compounds tend to have high reactivity because the constituent atoms have completely unbound valence electrons. Organic molecules can undergo various types of chemical reactions, such as substitution, elimination, or addition, which allow new compounds to form.

Most students have not been able to explain in detail and specifically why the carbon-oxygen bond tends to be the reaction center in organic compounds. The reaction can be analyzed by students in the transestrification reaction of used cooking oil. Students have not been able to predict the direction of the reaction and the transformation process of carbonyl groups in triglyceride compounds. This is because students do not understand the character of free electrons in oxygen and the Л bond in one of the carbon and oxygen double bonds. New students are able to study the polarity of the bonds formed due to differences in the electronegativity of the atoms. We can see this phenomenon in the description of the answers in Figure 3 below.

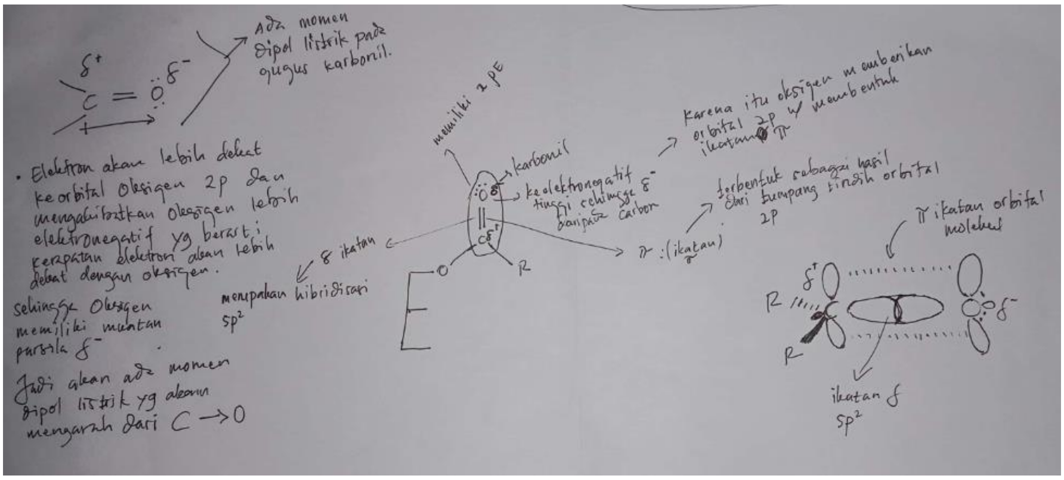

Figure 4. Students Description About Organic Compound Reaction and Bonding Formation

The Л bond characteristic of the carbon-oxygen bond in the carbonyl group is formed from the outermost orbital and electron. This is the basis for the reactivity and transformation of the Л bond in the synthesis of organic compounds. The basis of this concept has not been found by most students, so it is difficult to describe their reactions.

CONCLUSION

The conclusion describes the answer to the hypothesis and/or the purpose of the study or scientific findings obtained. The conclusion does not contain a repetition of the results and discussion, but rather a summary of the findings as expected in the objectives or hypotheses.

RECOMMENDATIONS

Conceptual learning with a visual approach, such as the application of computational chemistry, videos, flash can be used to increase students' conceptions in studying the molecular structure of organic chemistry. Contextually based problem-based learning methods around students can also be used to foster deep conceptions.

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