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# CHALLENGES FOR LEARNING CHEMICAL BONDING MATERIALS BASED ON THE CONCEPT OF ELECTROSTATIC INTERACTION AND THE OCTET RULE

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**ABSTRAK**

Penelitian ini bertujuan untuk mengidentifikasi hambatan yang dihadapi oleh siswa dan guru dalam materi ikatan kimia berdasarkan konsep interaksi elektrostatik dan aturan oktet. Metode penelitian menggunakan jenis penelitian kualitatif deskriptif. Teknik pada pengumpulan data penelitian ini yaitu dengan wawancara. Teknik analisis data yang digunakan ialah dianalisis menggunakan analisis isi induktif. Hasil penelitian menunjukkan beberapa faktor menjadi penyebab tantangan dan kesulitan belajar bagi siswa pada materi ikatan kimia. Yaitu faktor internal, faktor eksternal dan pemahaman siswa. Faktor internal yang menjadi tantangan siswa dalam pembelajaran materi ikatan kimia yaitu minat siswa itu sendiri. Hasil wawancara menunjukkan masih kurangnya minat siswa terhadap pembelajaran materi ikatan kimia. Faktor eksternal berupa metode pengajaran yang digunakan guru untuk meningkatkan efektivitas pembelajaran materi ikatan kimia yaitu dengan menggunakan metode pembelajaran diskusi informasi dan menggunakan alat peraga untuk menunjang pemahaman siswa. Ketersediaan sarana dan prasarana juga mejadi faktor penunjang dalam proses pembelajaran kimia. Hasil wawancara menunjukkan fasilitas yang digunakan masih kurang memadai sehingga pada pembelajaran kimia tidak pernah dilakukan eksperimen. Faktor terakhir yaitu pemahaman siswa. Hasil wawancara menunjukkan masih kurangnya pemahaman siswa terhadap materi ikatan kimia, kesalahan dalam pemahaman akan menyebabkan terjadinya miskonsepsi. Hasil wawancara guru menunjukkan masih adanya miskonsepsi pemahaman siswa terhadap materi ikatan kimia. Analisis data menunjukkan bahwa pemahaman mengenai prinsip aturan oktet dan interaksi elektrostatik masih tergolong rendah.

**ABSTRACT**

*This research aims to identify the obstacles students and teachers face in chemical bonding material based on electrostatic interactions and the octet rule. The research method uses descriptive qualitative research. The technique for collecting data in this research is interviews. The data analysis technique used was analyzed using inductive content analysis. The research results show that several factors cause challenges and learning difficulties for students in chemical bonding material. Namely internal factors, external factors, and student understanding. The internal factor that becomes a challenge for students in learning chemical bonding material is the student's own interest. The interviews showed that there was still a lack of student interest in learning chemical bonding material. External factors in the form of teaching methods teachers use to increase the effectiveness of learning chemical bond material are using information discussion learning methods and teaching aids to support students' understanding. The availability of facilities and infrastructure is also a supporting factor in the chemistry learning process. The results of the interviews showed that the facilities used were still inadequate, so experiments were never carried out in chemistry lessons. The final factor is student understanding. The interviews showed that students still lack understanding of chemical bonding material, and errors in understanding will cause misconceptions. Teacher interviews show that there are still misconceptions about students' understanding of chemical bonding material. Data analysis shows that understanding the principles of the octet rule and electrostatic interactions is still relatively low.*

**How to Cite**

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## INTRODUCTION

Learning is the teacher's effort to realize the process of acquiring knowledge, mastering skills, and forming student attitudes and beliefs (Hanafy, 2014). Learning is the process of providing material to students so that they can understand and comprehend it. The aim of the learning process is so that students are able to know and understand the meaning of the data, information and knowledge they obtain from trusted sources (Hakim, 2010). According to Slameto, there is a learning process in learning; in this learning process, there will be interactions in achieving learning goals, namely quality learning outcomes. However, to achieve learning goals, many obstacles are often encountered in daily learning activities, called learning difficulties.

Chemical bonding is a physical process that is responsible for the attractive interaction between two atoms/molecules, which causes a diatomic or polyatomic compound to become stable. The explanation of the attractive force is very complicated, explained by quantum electrodynamics. In practice, chemists usually explain chemical bonds based on quantum theory or qualitative explanations (but easier to explain). In general, a strong chemical bond is described by the transfer of electrons between two participating atoms. Chemical bonds keep molecules, crystals, and diatomic gases together. Apart from that, chemical bonds also determine the structure of substances (Roni, 2021).

Chemical interactions can occur through electrostatic interactions and the formation of covalent (complex) bonds. Electrostatic interactions occur when there is a relatively large difference in electronegativity between the metal ion & the atom that acts as a ligand. Covalent interactions occur if the difference in electronegativity between the metal ion and the atom that acts as an electron donor is relatively small or almost the same (Buhani et al., 2011). Electrostatic interaction is the interaction between two atoms that are not connected by a covalent bond, which occurs due to the presence of (partial) positive or (partial) negative charges on these atoms (Widjajakusuma et al., 2023).

The Octet Rule is a tendency for elements to have their electron configurations resemble noble gases. Noble gas elements (Gol VIIIA) have 8 (octet) or 2 (duplet, only Helium) valence electrons (Widodo et al., n.d.). The octet rule is the tendency of elements to have an electronic configuration in the outer shell of 8 electrons, such as the noble gases Ne, Ar, Kr, Xe, and Rn. The octet rule is that atoms tend to have eight electrons in the outermost shell. Electrons in chemical bonds play a role in achieving stability like noble gas elements.

Learning difficulties among students also occur in chemistry subjects. Chemistry is a complex and abstract science, and this makes students think that chemistry is a difficult subject (Woldeamanuel, M., Atagana, H., 2014). One of the materials taught in chemistry is chemical bonding in the odd semester of class X SMA/MA Science. Analyzing challenges in learning needs to be done so that barriers to student success that cause learning objectives not to be achieved can be clearly identified.

According to the results of an interview with a chemistry subject teacher at one of Tanjungpinang's senior high schools, "So far, it's been going smoothly," he said. The learning process on chemical bonding material did not experience any obstacles. Therefore, research is needed to examine the challenges in the student learning process regarding chemical bonds. Judging from the background above, the title of this research is "Challenges of Learning Chemical Bonding Material Based on the Concept of Electrostatic Interaction and the Octet Rule." This research aims to identify obstacles or challenges students and teachers face in chemical bonding material based on the concept of electrostatic interactions and the octet rule.

## METHODS

This type of research is descriptive

qualitative research. The research was conducted in the odd semester of 2023/2024. The population in this study was class XI Science at one of the State High Schools in Tanjungpinang. The sample used was 4 students of class XI Science at one of the State High Schools in Tanjungpinang. The technique used in collecting data for this research was interviews. An interview is a conversation carried out by two parties, namely the interviewer who asks questions and the interviewee who gives answers to those questions.

Interviews are carried out directly through face-to-face contact between the information seeker and the information source. When conducting interviews, researchers will collect data and information from research subjects. The interview technique carried out was a guided interview, namely an interview carried out with a complete and detailed interview guide instrument. Then, the data was analyzed using inductive content analysis, especially in data collection. In the next stage, the constant comparison method was used in accordance with the grounded theory approach. In the first stage of analysis, we used the conceptual construction classification for concepts, mnemonic devices, and explanatory schemes.

## RESULT AND DISCUSSION

This research was conducted by interviewing teachers and students. One chemistry teacher and four students participated.

**Table 1. Coding of research samples.**

| Students | Teachers |
|---|---|
| A1: Student 1 | G: Teacher |
| A2: Student 2 | |
| A3: Student 3 | |
| A4: Student 4 | |

**Table 2. Principles of explanation**

| Principles of explanation | Principles descriptions |
|---|---|
| PO | Octet Principles |
| PIE | Principles of electrostatic interaction |

Students' understanding of chemical bonding material can be seen in the following interview results in Table 3:

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**Table 3. Results of student interviews regarding chemical bonding material**

| quotation |
|---|
| I: What is your understanding of chemical bonds in high school? |
| A1: my understanding percentage it is 70-80%. |
| A2: Lack of understanding. |
| A3: I don't understand. |
| A4: This chemical bond is complicated; there are some easy parts and some difficult parts. So, when we want to understand something, we have to start with the main basics, such as the chemical elements. |
| I: What do you not understand regarding chemical bonds? |
| A1: There are no difficulties. The study is in class X, so there is some material that I forget because it is not repeated again. |
| A2: Covalent bond. |
| A3: Chemical bonds like changing formulas; the questions are often asked, and the teacher's writing is less visible or unclear. The subject of chemical bonding that is difficult to understand is metallic bonding because it has not been studied. |
| A4: Determine the number of molecules. |
| I: What reduces your interest in thinking about/studying chemical bonds? |

| quotation |
|---|
| A1: Because I don't understand chemistry. |
| A2: Because the material is difficult to understand. |
| A3: Many formulas. |
| A4: What motivates me is when I don't know the material being studied by the teacher and I have difficulty understanding it. That's what makes me less interested. |

The results of these interviews prove that some students still experience difficulties in understanding chemical bonding material. Students' difficulties in learning are situations where students cannot learn well, which is caused by obstacles. Each subject certainly has its own difficulties. According to (Ristiyani & Bahriah, 2016), chemistry subjects are considered difficult because chemistry contains material that is relatively new to students. Another factor that makes it difficult for some students to understand chemistry learning is the characteristics of chemistry, which are conceptual and computational, contain many formulas, and are tiered and interconnected. Learning chemistry also includes complex material because chemistry needs to be studied through three aspects, namely microscopic, sub-microscopic, and symbolic, and cannot be understood only through theory (Cardellini, 2012).

Learning difficulties are the conditions of a student who cannot demonstrate learning normally because the student has obstacles in the learning process. Barriers to the learning process can be caused by a lack of understanding and knowledge in students, both in written and oral form. In general, triggers for learning difficulties can be divided into two factors, namely internal factors and external factors. Internal factors come from the students themselves, while external factors come from outside the students. Students are said to have learning difficulties if they cannot master the subject presented by the teacher; this can be seen from the student's learning achievement, which is still relatively low.

The interviews' results led researchers to conclude that several factors trigger challenges and learning difficulties for students in chemical bonding material. The factors that challenge students' difficulties in chemical bonding material are internal factors, external factors, and students' understanding. The internal factor that challenges students in learning chemical bonding material is "interest," as seen from the interview results in Table 3. The students lack interest in learning chemistry, especially chemical bonding material, because, according to them, studying chemistry is difficult. Chemistry subjects are generally not liked by students because the material is abstract and difficult to describe. This is what makes it difficult for students to understand chemical concepts correctly (Prasetya & Priatmoko, 2011). Meanwhile, students' understanding of chemistry usually depends on information that can be seen.

External factors that become challenges in learning chemical bonding material are teaching methods. In the learning process, the role of the teacher greatly influences the development of student learning outcomes. Teaching methods can be a factor that can influence student learning outcomes. The lack of effectiveness of the teaching methods allocated by teachers to students influences students' interest and understanding in learning chemical bonding material.

**Table 4. Results of teacher interviews regarding teaching models**

| Quotation |
|---|
| I: What teaching model do you use to implement explanatory schemes in chemical bonding material? |
| G: I will use information discussion to convey how to achieve stability. When a bond has occurred, I will experiment in class using props. |
| I: What schemes serve as explanatory schemes when you teach chemical bonding? |
| G: Using props makes it easier for students to understand the material. |
| I: Have you detected any alternative explanations or misunderstandings by students? For example? |

G: The misconception among students is that putting together a Lewis structure is usually difficult. For example, $HNO_3$ is quite complicated, and it is difficult for students to determine where the H electrons are and where the N electrons are.

Teaching methods are strategies used as tools to achieve teaching and learning goals. The right teaching method chosen and defined will produce effective and efficient education. Teaching methods also differ for specific teaching objectives. Teachers must understand and learn teaching methods so that they can convey the material well and students understand it well. This teaching method can be made as interesting as possible so that students gain knowledge effectively and efficiently (Dewi & Lestari, 2021).

Errors in students' understanding of chemical bonds can lead to errors in understanding. Continuous errors in understanding will lead to conceptual errors (Genes et al., 2021). An individual's ability to understand material after knowing and remembering it is known as conceptual understanding. Understanding concepts is considered more vital because, through this understanding, students can effectively master, absorb, and retain information for the long term. Focusing on understanding concepts is crucial, especially in the context of chemistry learning. A good understanding of material concepts helps students understand the subject matter in more depth, making it easier for them to learn chemistry as a whole. Therefore, it needs to be emphasized that each learning session should emphasize students' mastery of concepts regarding the material, aiming to build a solid and correct foundation for obtaining the basic abilities or competency standards set.

Second, the lack of facilities in the learning process can be seen from the results of the following interview. To fulfill students' competency in chemistry subjects, they require practical work in the laboratory. This means that students have to study chemical materials theoretically and carry out practical work in the laboratory with the necessary practical facilities, tools, and materials (Wiratma & Subagia, 2014). Apart from that, it is stated that practical activities aim to increase knowledge of scientific processes, problem-solving, and theory (Ural, 2016).

The next factor that becomes a challenge in learning chemical bonding material is student understanding. It can be seen from the interview results in Table 3 that students still lack an understanding of chemical bonding material. Chemistry teachers and students say that chemistry is one of the most complicated materials to understand because the concepts are interconnected. One of the main difficulties is that students can only repeat the definitions of terms in the chemical bond material, but they do not really understand their meaning. They may also be unable to apply these concepts and are more likely to rely on what they remember (Lukum et al., 2023).

**Table 5. Students' understanding regarding the principle of octet order**

| Quotation | Code |
|---|---|
| I: What bonds do you think are found in water?<br>A1: In water, the bonds that exist are covalent.<br>I: What bonds do diamonds have?<br>A1: In diamonds, there are ionic bonds.<br>I: What bonds are present in sodium chloride (NaCl)?<br>A1: The bonds contained are covalent.<br>I: Lastly, what type of bond is found in magnesium ribbon?<br>A1: Metal bond type.<br>I: Determine the chemical stability of the following particles:<br>a. $Na^+$ ion<br>b. Na<br>c. $Na^{-7}$ ion<br>What is the order from most stable to least stable?<br>a. $Na^+$, Na, $Na^{-7}$ | PO + PIE |

| Quotation | Code |
|---|---|
| b. Na, $Na^+$, $Na^{-7}$<br>c. $Na^+$, $Na^{-7}$, Na<br>A3: b. Na, $Na^+$, $Na^{-7}$<br>I: Why did you choose option b?<br>A3: Because Na itself has not been mixed so it is still stable | |

This means that most of the students' answers still do not understand the principles of the octet rule and electrostatic interactions. Where two answers are still not correct. From the second answer, students were unable to explain the concept of the octet rule and electrostatic interactions. For the second question in determining the chemical stability of these particles, we can look at the concept of electron configuration and the octet rule (for non-metal atoms) or the duet rule (for hydrogen and helium) in forming ions. $Na^+$: This is a sodium ion that has lost one electron. Although the loss of electrons gives it a positive charge, its electron configuration mimics that of the noble gas neon, which is a very stable state. Na: Sodium in atomic form is a neutral atom that has one valence electron. Although not as stable as $Na^+$ ions, sodium atoms have a relatively stable electronic configuration. $Na^{-7}$: This sodium ion is supposed to have seven extra electrons. This condition does not comply with the octet rule or duplet rule and makes this particle less stable.

**Table 6. Understanding the principles of the octet rule**

| Quotation | Code |
|---|---|
| I: Which of the following best describes the structure of the hydrogen molecule?<br>a. H: H<br>b. H :H<br>A2: The answer is a.<br>I: Can you give a reason why you chose to answer a?<br>A2: Because it's equal.<br>I: Which one is easier to donate its outer electrons to?<br>a. Lithium<br>b. Natrium<br>A2: Sodium.<br>I: Why sodium?<br>A2: Because sodium has an outer shell that is farther from the atomic nucleus and because Na can donate electrons to other elements | PO |

From the results of the analysis of students' answers, these students were able to apply the octet rule when answering questions. However, he has not been able to provide an explanation for the answer. For the first question, the colon (:) indicates that a pair of electrons is shared or shared between two hydrogen atoms to form a covalent bond, which is where two hydrogen atoms share one pair of electrons to achieve the noble gas electron configuration. For the second question, sodium tends to donate its outer electrons more easily because sodium has an outer shell that is farther from the atomic nucleus.

**Table 7. Understanding the principles of electrostatic interactions.**

| Quotation | Code |
|---|---|
| I: What factors influence the bonds formed in the following cases: why are the bonds in table salt different from those of salt in water?<br>A3: Table salt contains the element NaCl. The bonds that occur are covalent bonds, namely bonds that occur between ions and ions.<br>I: Which of the following best describes what is being shared by the Hydrogen fluoride electron pair?<br>a. H: F<br>b. H :F | PIE |

| Quotation | Code |
|---|---|
| A4: The answer is a.<br>I: Give reasons why you chose option a?<br>A4: Because the sum of the numbers in the front number and the back number is the same.<br>I: Which attracts electrons more strongly, nitrogen (N) or fluorine (F)?<br>A2: Nitrogen.<br>I: Which attracts electrons more strongly, fluorine (F) or bromine (Br)?<br>A1: Fluorine. | |

This means that most students do not understand the concept of electrostatic interactions in depth. In the second question, the correct option b shows that the electron pair is shared between the hydrogen and fluorine atoms in the HF molecule. In the third question, fluorine attracts more electrons than nitrogen. This is caused by an increase in the positive charge of the atomic nucleus, which makes fluorine have a greater electron attraction than nitrogen. And in the last question, the one that attracts electrons more strongly is flour because in one group, from top to bottom, the electron affinity gets smaller. Thus, flour has the greatest electron affinity.

## CONCLUSION

From the research results, it can be concluded that there are several factors that challenge students' difficulties in chemical bonding material, namely internal factors, external factors, and student understanding. The internal factors that challenge students in learning chemical bonding material are the student's own interests. The results of the interviews show that there is still a lack of student interest in learning chemical bonding material. External factors in the form of teaching methods used by teachers to increase the effectiveness of learning chemical bond material are using information discussion learning methods and using teaching aids to support students' understanding. The availability of facilities and infrastructure is also a supporting factor in the chemistry learning process. From the results of the interview, it shows that the facilities used are still inadequate so that experiments are never carried out in chemistry lessons. The final factor is student understanding.

Students' understanding of a concept will help them understand, absorb, and retain the information obtained. The interview results show that students still lack understanding of chemical bonding material, and errors in understanding will cause misconceptions. The results of teacher interviews show that there are still misconceptions about students' understanding of chemical bonding material. Data analysis shows that understanding of the principles of the octet rule and electrostatic interactions is still relatively low.

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