Analyzing the Difficulties Students Face in Comprehending Fundamental Concepts in the Field of Atomic Structure and Chemical Bonds in the Basic Chemistry Course

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Abstract. This study aimed to examine the difficulties that students encounter in comprehending fundamental concepts related to atomic structure and chemical bonds in the Basic Chemistry course. Population from study is student Chemistry Department FMIPA Unimed in 2022/2023. Determination of the sample study used random sampling. The sample in the study consisting of 80 students from 3 classes, namely: PSPK22C, CESP22, and PSKM22B. The results of the study show that average value for CESP22 class, PSPK22C, and PSKM22B respectively is 70.167; 56.621; and 54.212, meanwhile average value for third class is 58,675 (categories low). The materials with the level low and very low mastery are: Bohr atomic model, atomic mechanics model wave, Atomic Properties, Formation process ionic bond, Formation process bond covalent, and Shape molecule. Material Numbers quantum, Properties ionic compounds, and Exceptions octet rule on formation bond covalent in category good and very good.

Keywords: Atomic Structure, Chemical Bonds, Difficulties Students, and Fundamental Concepts.

1 Introduction

For students in the Chemistry Department, the Basic Chemistry course is a basic course. The aim of this course, like other basic courses, is to equip students with various basic concepts within the scope of chemistry. The competencies obtained from Basic Chemistry courses can be used as a solid foundation for studying advanced chemistry courses. Good mastery of basic materials will make it easier for students to study various chemical materials at a higher level. Ausubel's theory of meaningful learning suggests that providing this basic material will enhance the meaning of learning in the following material. Bearing in mind the importance of mastering basic material, several universities have instituted policies regarding the management of basic lectures through Joint Preparation Levels (TPB) or similar.

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The material discussed in the Basic Chemistry course is atomic structure, chemical bonds, reaction rates, redox, and electrochemistry, and metallurgy. The subject matter that will be discussed in this research activity is Atomic Structure and Chemical Bonding. The material discussed in both topics is material that is very fundamental in the overall structure of chemical materials. Mastering these two materials well will make it easier for students to study chemical concepts at a higher level. The characteristic of these two materials is that they are abstract so that we cannot see with the naked eye various events involving atomic structure or the process of forming chemical bonds. Various events on a molecular scale can only be detected on a macroscopic scale using chemical instruments or directly. Due to the abstract characteristics of this material, various efforts are needed to create various molecular models that can be sensed by students, so that students can more easily understand these concepts.

An investigation of topics in chemistry according to students in Ireland. This research was conducted on students aged 15/16 years to university level aged 18+. This research was carried out using a Likert type questionnaire which included the topics discussed in chemistry lessons. The research results show that the topics that are considered difficult are Volumetric Analysis Calculations, Redox Reactions and Solution Concentration. The selection of difficult or very difficult topics is influenced by students' mathematical abilities, as evidenced by other findings [1]. Analysis of terminology difficulties faced by students when studying chemistry. The four cases of non-technical terms analyzed in this work are as follows: a) non-technical words common in the science school environment; b) meta-representational verbs; c) connecting items; d) teleological or intentional terminology [2].

The success of education, whose main goal is to increase human resources, is influenced by various factors. One of the factors that influences this success is the teacher's ability to carry out and utilize assessments, process evaluations and learning outcomes [3]. Assessment is an effort to collect data or information using multi techniques and multi sources which are used as a basis for decision making [4]. The purpose of this assessment is to assess how well learning objectives have been achieved according to the learning plan [5]. The use of an assessment rubric during the learning process is necessary to obtain credible and impartial assessment results [6].

The application of assessment and the learning outcomes process is a teacher's activity in making decisions regarding achieving competency goals for students who have different individual characteristics during the learning process [4]. Assessment is an inseparable part of the teaching and learning process and is an important component of the curriculum. Assessment functions as an aid for teachers in placing students into certain groups, improving teaching methods, measuring student readiness (attitude, mental and material readiness), providing guidance and selection for determining majors, and the information obtained will help students. teachers in order to create better education [7].

The process of assessment involves evaluating and interpreting evidence of student performance that can be used by students and their teachers to determine the extent to which they have absorbed the learning process [8]. In order to ensure that students experience the learning process correctly, teachers must be aware of their students' learning development. The learning process is prioritized in assessment, so the data collected must come from actual activities performed by students during this process.

The purpose of assessments is to gauge the level of achievement of learning indicators and collect information on students' progress in various aspects. Assessment is used as a tool to measure the level of learning success and achievement of learning goals. According to Douglas [10], assessment is a method used to measure a person's abilities, knowledge or performance. Assessment is an ongoing process that covers a wider domain. Based on several definitions that have been explained, it can be concluded that assessment is a systematic and continuous process or activity to collect information about student learning processes and outcomes in order to make decisions based on certain criteria and considerations with the aim of making improvements and determining success..

The assessment aims to provide feedback regarding student learning progress, both for students, parents and teachers as well as improving learning and student development [11]. According to Popham [12] and Stecher et al [13], there are three objectives of assessment, namely (a) to develop learning and teaching, (b) certifying individual abilities, and (c) evaluating program success.

An analysis of 150 students aged 15 to 16 years was conducted to examine their difficulties in understanding conservation problems in open and closed system chemical reactions. The research findings reveal that students possess several misconceptions, including: The precipitation reaction results in decreased total mass due to the solid and heavier precipitate formed compared to the liquid [14]. Analysis of the topic of atomic orbitals, molecular orbitals, shows that topics that are not well mastered are atomic orbitals and molecular orbitals with Slater determinants, similarities between real forms and mathematical equations of atomic orbitals, variations in the representation of atomic orbitals, and approaches to atomic orbitals from atoms. with lots of electrons [15].

Analyzing the challenges faced by students when studying the topic of organic reaction mechanisms. Interviews were conducted with 12 undergraduate chemistry students who solved problems on nucleophilic substitution and elimination reactions to provide examples and test the classification. The research findings indicate that some students may not benefit from general support to address reaction mechanisms and require more tailored support [16]. The ability to develop reaction mechanisms using electron driving formalism (EPF). Several studies suggest that undergraduate and even postgraduate students face difficulties when trying to propose mechanisms for using EPF [17]. The Perry Intellectual Development Model as a framework was used to analyze students' difficulties in learning organic chemistry, revealing that organic chemistry students function as dualistic thinkers [18].

Analyzing the challenges that students face when learning about factors that affect reaction rates. At a high school in Bandung, 60 students in class XI were the subject of this research. According to the descriptive analysis, students are knowledgeable about the factors that influence reaction rates, but they do not comprehend them These findings indicate that students are still unaware of how these factors impact reaction rates. Further investigation is needed to find out how to overcome students' learning difficulties related to factors that influence reaction rates [19]. The level of understanding and difficulty of the subject in molecular geometry is assessed by conducting a respondent ability test. The research findings show that molecular geometry material is prone to 7 types of difficulties. The three biggest difficulties experienced by students were that 71% of students did not understand the meaning of the Lewis symbol. The influence of lone pairs on molecular geometry is not understood by

65% of students. When asked about the placement between name and molecular geometry, 31% of students were unable to comprehend the various types of molecular geometry [20].

2 Research methods

Location and Time of Research

This research was carried out in May - June 2023 at the Department of Chemistry, FMIPA, Medan State University, North Sumatra

Population and Sample

The population in this study were all second semester students at the Department of Chemistry, FMIPA, Medan State University who took the Basic Chemistry course. Sample selection was carried out randomly with the assumption that the abilities of the students in each class were relatively the same. The number of samples in this study was 80 students consisting of 3 classes, namely: Chemistry Education Study Program regular class (PSPK 22C and bilingual (CESP 22), and 1 Chemistry Study Program class (PSKM 22B). The samples used represent the Study Programs involved. currently owned by the Chemistry Department, FMIPA Unimed.

Instrument Study

The instrument used in this research is a test to determine the level of students' comprehension of concepts related to atomic structure and chemical bonds. The subject of atomic structure and chemical bonds is covered by a grid of questions in **Table 1**.

Table 1. Test question grid.

No	Field of Study	No Question Items	Cognitive Level
1	Bohr model of the atom	3, 4	C3, C4
2	Mechanical atomic model wave	1, 2	C5, C4
3	Configuration electron in atoms	6, 8	C4, C5
4	Number quantum	5,	C4
5	Atomic Properties	7, 9,	C3, C4
6	Rule octets and duplet on formation bond chemistry	10,	C3
7	Forming process ionic bond	11, 14	C4, C5
8	properties _ ionic compound	15	C4
9	Forming process bond covalent	13, 16	C5, C4
10	Differentiate ionic bonds and bonds covalent	12	C3
11	Exception octet rule on formation bond covalent	17	C3
12	Form molecule	18, 19, 20	C3, C4, C4

3 Results and Discussion

In this section, the research data that has been obtained in this research activity is presented. As stated in the research methodology section, the sample for research activities consisted of three classes, namely: CESP 22, PSPK 22C, and PSKM 22B. **Figure 1** presents data on the learning outcomes of the CESP 22 class on atomic structure and chemical bonds.

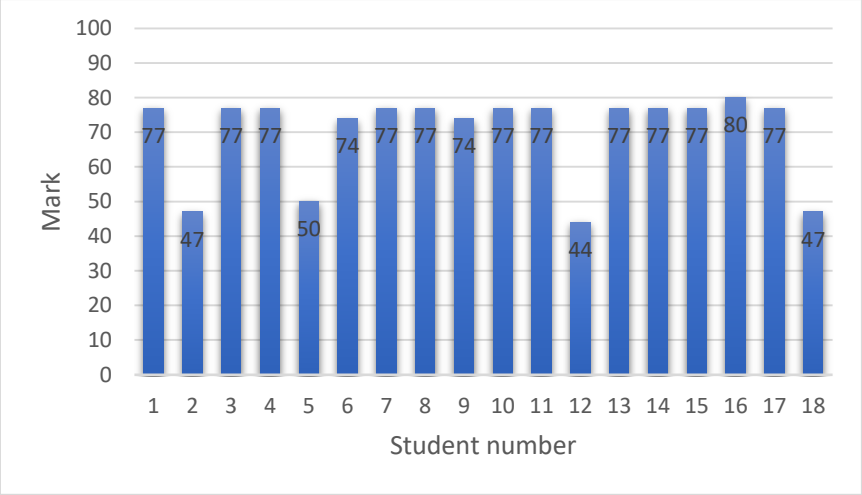

Fig. 1. Learning about atomic structure and chemical bonding in the CESP 22 class

The average score for learning outcomes related to atomic structure and chemical bonds is 70.167. On average, CESP 22 class students gave grades in the sufficient category, although from the data it was still found that there were four people who got grades in the poor category. Data on learning outcomes related to atomic structure and chemical bonds for the PSKM 22B class is presented in **Figure 2**.

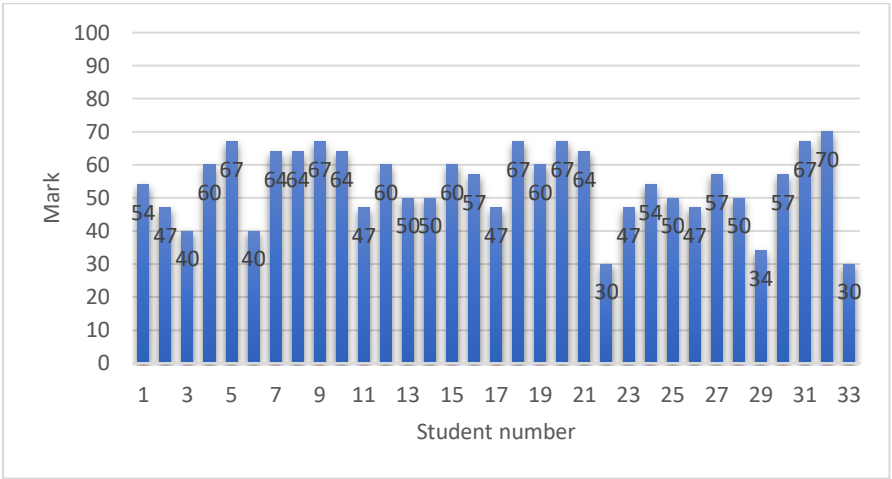

Fig. 2. The results of learning atomic structure and chemical bonding for PSKM 22B class

The average learning outcomes for the subject of atomic structure and chemical bonds are 54,212. On average, PSKM 22B class students gave grades in the poor category, although from the data it was still found that there was one person who got a grade in the sufficient category. Data on learning outcomes for the atomic structure and chemical bonds class in PSPK 22C are presented in **Figure 3**.

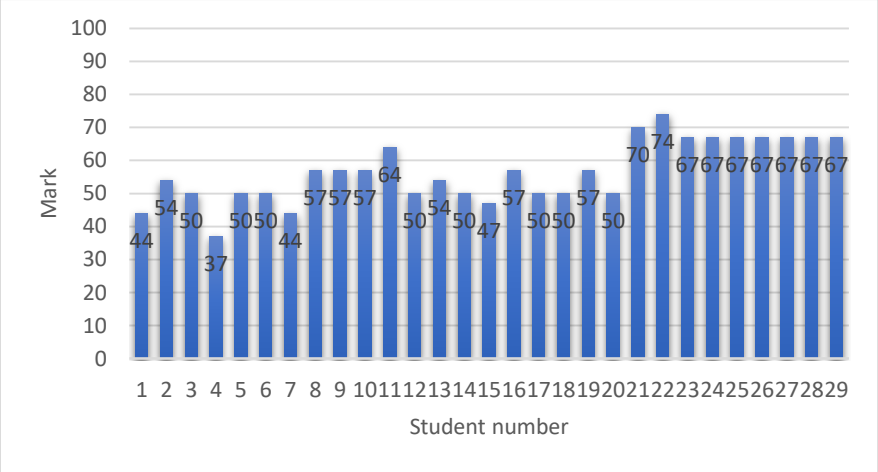

Fig. 3. The results of the PSPK 22C class's study of atomic structure and chemical bonds

The average learning outcomes for the course on atomic structure and chemical bonds are 56.621. On average, PSPK 22C class students gave grades in the poor category, although from the data it was still found that there were two people who got grades in the sufficient category. The total average score for the three classes is 58,675 in the poor category. The average score for student learning outcomes on the subject of atomic structure and chemical bonds is in the poor category, to enhance the quality of students' understanding of the material on atomic structure and chemical bonds, various efforts are needed.

The material of atomic structure and chemical bonds is material that must be mastered well by Chemistry Department students, because this material is the material that really underlies students' understanding of other concepts, especially regarding the properties of molecules. Students will experience difficulties in understanding the properties of organic compounds, inorganic compounds and macromolecules if the student's understanding of atomic structure and chemical bonds is not good. Judging from the abstract characteristics of these two materials, various efforts are needed to make the material more real and easy for students to understand.

Analysis activities on learning outcomes on the subject matter of atomic structure and chemical bonds are also carried out through in-depth analysis activities on sub-subjects that have low uptake values or determining sub-subjects that are considered difficult by most students. These results will provide an idea for lecturers to improve the quality of learning on this sub-subject. The subject of atomic structure and chemical bonds is covered by data on student learning outcomes in **Table 2**.

Table 2. The outcomes of student learning in relation to materials that deal with atomic structure and chemical bonds.

No	Field of Study	Average Material Mastery
1	Bohr model of the atom	25.95
2	Mechanical atomic model wave	24,8
3	Configuration electron in atoms	73,1
4	Number quantum	91.9
5	Atomic properties	33,15
6	Rule octets and duplet on formation bond chemistry	79.3
7	Forming process ionic bond	40,9
8	Properties ionic compound	91
9	Forming process bond covalent	47.5
10	Differentiate ionic bonds and bonds covalent	78.4
11	Exception octet rule on formation bond covalent	81
12	Form molecule	54,33
	Total average	60,111

Table 2 reveals that the Bohr atomic model is one of the three sub-topics that have very low learning outcomes, wave mechanics atomic model, and properties of atoms. Sub-topics: The process of forming ionic bonds, the process of forming covalent bonds, and the shape of molecules in the low category. There are three sub-topics which are included in the sufficient category, namely the sub-topic of electron configuration in atoms, octet and duplet rules in the formation of chemical bonds, and distinguishing between ionic bonds and covalent bonds. Sub-topics of quantum numbers, properties of ionic compounds, and exceptions to the octet rule in the formation of covalent bonds in the good and very good categories.

Bohr atomic model material, wave mechanics atomic model, atomic properties. The sub-topics of ionic bond formation processes, covalent bond formation processes, and molecular shapes are included in the low and very low categories. If you look closely at the materials that are classified as very low level, they are the Bohr atomic model, the wave mechanics atomic model, the properties of atoms are the material that really underlies students' understanding. Therefore, various efforts are needed to improve students' understanding of these materials. The results of student ability tests are the basis of the data obtained in this research activity. To confirm these results, further investigation is needed through interviews or questionnaires with students.

4 Conclusion

The research results show that the average score for the CESP 22, PSPK 22C, and PSKM 22B classes respectively is 70.167; 56,621; and 54,212, while the average score for the three classes was 58,675 (poor category). Materials with low and very low levels of mastery are: Bohr's atomic model (25.95%), Wave mechanics atomic model (24.8%), Atomic Properties (33.15%), Process of forming ionic bonds (40.9%), Process of forming covalent bonds (47.5), and Molecular shape (54.33). Material included in the sufficient category is the sub-topic of electron configuration in atoms (73.1), octet and duplet rules for the formation of chemical bonds (79.3), and distinguishing between ionic bonds and covalent bonds (78.4). Material

Quantum numbers (91.9), Properties of ionic compounds (91), and Exceptions to the octet rule in the formation of covalent bonds (81) are in the good and very good categories.

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