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EXPLORING THE CORRELATION BETWEEN CHEMICAL ABSTRACTION ABILITY AND STUDENT LEARNING OUTCOMES: A QUANTITATIVE ANALYSIS IN HIGH SCHOOL CHEMISTRY LEARNING

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Abstract. Chemical abstraction ability is closely related to students' cognitive style and is believed to have an impact on learning outcomes. This study examines the correlation between abstraction ability and student performance in chemical bonding. Addressing the gaps in previous research, this study focuses on the specific role of abstraction in chemistry learning. The research, conducted at Madrasah Aliyah Negeri 2 Kampar, used quantitative methods with a correlation approach. A purposive sample of 23 students of class XI IPA 2 was analyzed, showing a significant positive correlation (rxy = 0.708) exceeding the rtable value at 5% (0.433) and 1% (0.549) significance levels, leading to acceptance of Ha and rejection of H_0. These findings highlight the need for visualization and modeling-based teaching strategies. Using visual aids, interactive simulations, and problem-solving approaches can improve students' understanding of abstract chemical concepts.

Keywords: abstraction ability, chemical bond, learning achievement

INTRODUCTION

Most chemical concepts are abstract, which means “something intangible” or “only logical images” and related to thinking patterns. One of the abstract chemistry subjects is chemical bonding material. Chemical bonding material is one of the chemical subject matter that contains abstract concepts (Fitriyani et al., 2019; Martini, 2023). This makes students have difficulty understanding chemical bonding material (Hasanah et al., 2023; Priliyanti et al., 2021). In learning about chemical bonds, students are directed to master and understand concepts that include the process of ionic bonds, covalent bonds, coordination covalent bonds, and metal bonds, such as atoms, ions, and molecules, as well as matter and its relationship to the physical properties of the material itself(Hasanah et al., 2023; Husni, 2022).

Based on the results of research, it was found that students have difficulty in understanding and distinguishing compounds with ionic and covalent bonds (Kristiana et al., 2020). This difficulty increases when they are faced with more complex material such as single, double, and triple covalent bonds, as well as the concept of coordination, polar and non-polar, which makes it even more difficult for students to understand and distinguish the type of bond of the compound, especially if they only rely on memorization methods (Rusianti et al., 2019; Widarti et al., 2018). The abstract concept of chemical bonding actually requires logical reasoning to be well understood (Sibomana et al., 2020).

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Abstract thinking involves the use of symbols that help us in dealing with various special situations when solving problems (Nurrahmah et al., 2021). Dalam In this process, it is important to consider the effective use of these concepts (Sugandi et al., 2020). In addition, abstract thinking also includes the ability to generalize and structure the problems we face in everyday life, which is ultimately part of the process of abstraction itself (Wulandari, 2017).

In the Big Indonesian Dictionary, abstraction is defined as the process or act of separating. The word "abstraction" has two meanings: first, as a process of "describing" a situation, and second, as a concept as a result of a process. Pier Luigi Ferrari states that "*we can see that very often abstraction is a basic step in the creation of new concepts,"* which means abstraction is often a basic step in creating new concepts, and often new objects appear. Abstraction is an idea or ideas used to describe, understand, and simplify the world. In understanding some things that are unclear or difficult to describe in real terms, the object requires abstraction or abstract concepts of thought (Murtiningrum et al., 2019).

According to Piaget, there are two possibilities for abstraction, namely simple abstraction (empirical) and reflective abstraction, distinguishing abstraction into two types, namely empirical abstraction and theoretical abstraction (Nadilia & Wijayanti, 2023). Broadly speaking, abstraction can be divided into three types, namely reflective abstraction, empirical abstraction, and theoretical abstraction. In this study, the abstraction used is reflective abstraction to describe students' abstraction skills in solving chemical problems. Suggested levels or stages of reflective abstraction activity according to Cifarelli are defined as follows: the first level is recognition, the second level is representation, the third level is structural abstraction, and the fourth or highest level is structural awareness (Masamah, 2021; Wiryanto, 2019).

Students' ability to abstract in solving problems is important, because this abstraction process helps them understand a solution (Nihayah, 2021). In the process of problem-solving a situation, students often connect the activity to the next problem-solving situation. Given the characteristics of chemical concepts that tend to be difficult and complicated (Rohayah, 2022). This requires a high level of abstraction ability from students in understanding and internalizing the knowledge (concepts) gained during the learning process (Hurriyyah & Muzdalipah., 2024).

However, research on abstraction ability in chemistry learning is still limited. Therefore, this study aims to analyze the relationship between chemical abstraction ability and student learning outcomes in chemical bonding material. The problem formulation in this study is whether there is a significant relationship between abstraction ability and student learning outcomes, and how the relationship can be explained in the context of chemistry learning.

RESEARCH METHOD

This research is a correlational study with a quantitative descriptive method (Sholeh et al., 2022). The independent variable is chemical abstraction ability, while the dependent variable is student learning outcomes (Pratama et al., 2023). The research was conducted at Madrasah Aliyah Negeri 2 Kampar with the subject of class X IPA 2 students selected using purposive sampling, namely the selection of subjects based on certain criteria relevant to the research objectives (Priliyanti et al., 2021).

Data were collected through chemical abstraction ability tests, semester exam results, and student interviews. Data analysis was carried out through the stages of reviewing test results, interviews, observations, and documentation.

Furthermore, the data were analyzed by comparing theory and research results, ending with hypothesis testing to determine the relationship between abstraction ability and student learning outcomes (Nihayah, 2021; Rusandi & Rusli, 2021).

RESULTS AND DISCUSSION

The results of the abstraction ability test obtained by students on chemical bonding material are in Figure 1.

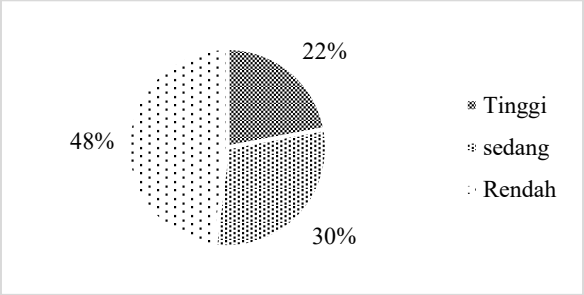

Figure 1. Percentage score of students' abstraction ability

Based on the percentage listed in Figure 1. The chemical abstraction ability of students in class X IPA 2 Madrasah Aliyah Negeri 2 Kampar is still in the low category, characterized by the highest percentage in the low group. From the score of students' abstraction ability, the percentage of the low category is 48%; this is due to students having difficulty in solving the problem. In addition, the nature of the chemical bond material itself, which is abstract, is also because students do not read and understand the problem well, are less careful, and tend not to actively think about solving chemical bond problems. Furthermore, the researchers carried out a series of analyses of three students selected based on the achievement category as well as the results of student answers and interview results, which the author considered could show the level of students' chemical abstraction ability. The categories of students' chemical abstraction abilities analyzed include high (student A), medium (student B), and low (student C). Based on the results of student interviews presented in Appendix M and the results of student answers in the written test regarding the abstraction ability of chemical bonding material, it is analyzed as follows:

1. The abstraction process that occurs in student A
   The results of student A's research with high abstraction ability are in Table 1.

Table 1. Analysis result of abstraction ability of student A

No	Reflective Level of Abstraction	Analysis
1	**Recognitive**	Based on the interview results in appendix M1, it can be seen that student A can remember the previous material, namely the atomic structure and periodic table of elements related to chemical bonds. Student A is also able to understand the questions given well.
2	**Representation**	Based on the results of the interview, Student A was able to understand the question so that he answered and solved the chemical bond problem classified as easy, medium, and difficult, and Student A was also able to convey the results of his thinking into chemical symbols and chemical structures, such as making electron configurations and Lewis structures.

No	Reflective Level of Abstraction	Analysis
3	**Structural Abstraction**	Based on the results of the interview, it can be seen that student A can solve chemical bonding problems by applying new strategies or other methods in solving them.
4	**Structural Awarenesss**	The results of the interview showed that Student A realized his ability to anticipate the results of problem solving, was able to provide conclusions and arguments or reasons appropriately for the decisions taken, and reflected on these decisions for further activities.

From Table 1, Student A shows a good understanding of the given problem so that he is able to perform abstraction quickly. This student succeeded in representation abstraction, was able to answer questions with various levels of difficulty, and expressed his thoughts in the form of chemical symbols and structures such as electron configuration and Lewis structure. In addition, at the structural abstraction level, Student A can develop new strategies for solving problems and provide strong arguments for his decisions.

The results of the abstraction ability test obtained by student A on high chemical bonding material are in Figures 2, 3, and 4.

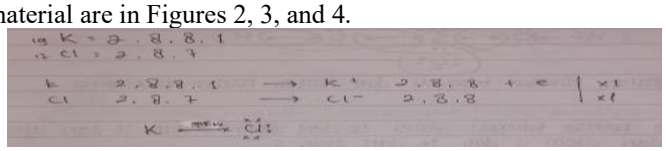

Figure 2. Appendix M1 Easy Category Problem, Describing the Shape of the Ion Bond KCl

From Figure 2. Shows that student A can understand the problem given well so that he can think or do abstraction quickly. Student A did a good job with the representation of abstraction, namely being able to answer and solve chemical bond problems in the easy category.

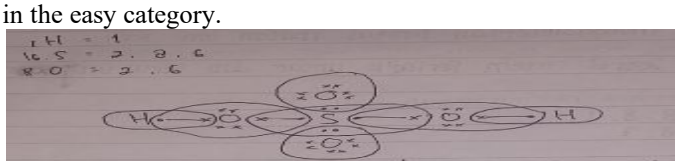

Figure 3. Appendix M1 Medium Category Problem: the type of covalent bond found in the compound H_2SO_4

From Figure 3, Student A is able to express the results of his thinking on moderate category problems in the form of chemical symbols and chemical structures, such as making electron configurations and Lewis structures, and also transforming information or structures into chemical models in the form of words. Furthermore, student A has good ability at the structural abstraction level because he is able to develop new strategies for a problem.

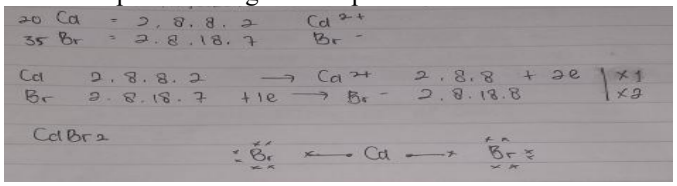

Figure 4. Appendix M1 Hard Category Problem, Find the formula of the ionic compound between the elements Ca and Br

From Figure 4, student A is able to express the results of his thinking on difficult category problems in the form of chemical symbols and chemical structures, such as making electron configurations and Lewis structures, and it can be seen that student A is aware of his ability to anticipate the results of problem solving, able to provide conclusions and arguments or reasons correctly for the decisions that have been made, and reflect on decisions made for the next activity.

2. The abstraction process that occurs in student B
   The research results of student B with moderate abstraction ability are in Table 2.

Table 2. Analysis result of abstraction ability of student B

No	Reflective Level of Abstraction	Analysis
1	**Recognitive**	Based on the interview results in appendix M2, it can be seen that student B is able to recall the previous material, namely the periodic system of elements related to chemical bonding problems.
2	**Representation**	Based on the results of student B's answer sheet and interview results, it can be seen that student B is able to answer and solve chemical bonding questions but has little difficulty in answering difficult category questions. Student B can also express his thoughts in chemical symbols and chemical structures, such as making electron configurations and Lewis structures.
3	**Structural Abstraction**	Based on the results of the interview, it can be seen that student B can solve chemical bonding problems by using new strategies or other methods in solving them.
4	**Structural Awareness**	Based on the results of the interview, it can be seen that student B is able to provide arguments or reasons for the right decision.

From Table 2, student B is able to understand the problem and identify the structure of the problem, although the understanding and connection are still not strong, so the abstraction process is sometimes slow but can also be fast. This student can reflect on previous activities and reapply them to the problem at hand. In addition, Student B can convey the results of his thinking in the form of chemical symbols and structures such as electron configuration and Lewis structure. Although able to develop new strategies in problem solving, this student tends to have difficulty in understanding more complex problems. However, he is still able to provide the right argument or reason for his decision.

The results of the abstraction ability test obtained by student B on the chemical bonding material are shown in Figures 5, 6, and 7.

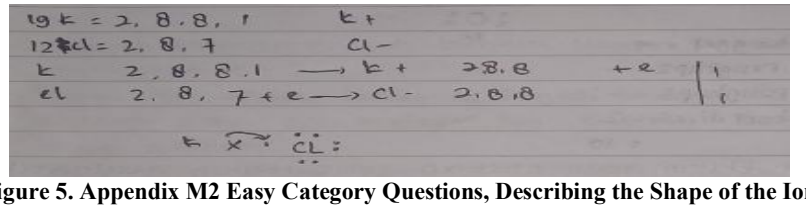

Figure 5. Appendix M2 Easy Category Questions, Describing the Shape of the Ion Bond KCl

Figure 5 shows that student B can understand the easy category problem or identify the structure of the problem and connect it to a little less understanding; this gives rise to a slightly long abstraction, but sometimes the abstraction that appears in student B is fast.

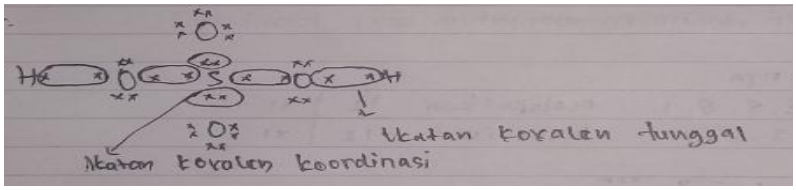

Figure 6. Appendix M2 Medium category questions, the type of covalent bond found in the compound H_2SO_4

From Figure 6, Student B is able to answer medium-category questions and recall previous activities and reapply them to the problem at hand. Student B can express the results of his thinking in the form of chemical symbols and chemical structures, such as making electron configurations and Lewis structures, and answer questions well about the types of chemical bonds in H_2SO_4 compounds.

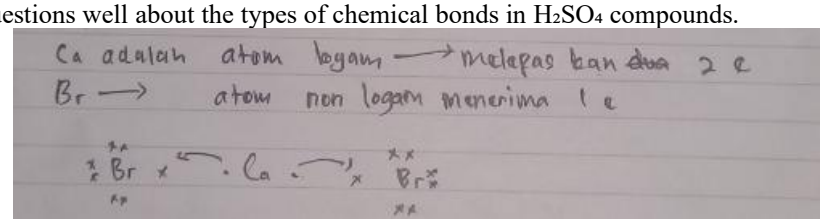

Figure 7. Appendix M2 Hard Category Questions, concluding that the elements Ca and Br compound $CaBr_2$ ions that are ionic bonded

From Figure 7, it can be seen that student B is able to answer and solve chemical bonding questions but has little difficulty in answering difficult category questions, and student B can also express the results of his thinking in chemical symbols and chemical structures, such as making electron configurations and Lewis structures.

3. The abstraction process that occurs in student B

The research results of student C with low abstraction ability are in Table 3.

Table 3. Analysis result of abstraction ability of student C

No	Reflective Level of Abstraction	Analysis
1	**Recognitive**	Based on the interview results in appendix M3, it can be seen that student C cannot re-understand the previous material related to chemical bonding material and takes a long time to come up with the material.
2	**Representation**	Based on the results of student C's answer sheet and interview results, it shows the ability to answer and solve chemical bonding questions in the easy and medium categories but cannot solve chemical bonding questions that are classified as difficult. Student C is able to express his thoughts in the form of chemical symbols and chemical structures, such as compiling electron configurations and creating Lewis structures.

No	Reflective Level of Abstraction	Analysis
3	**Structural Abstraction**	Based on the interview results, it can be seen that student C cannot develop new strategies or methods in solving chemical bond problems that are classified as difficult.
4	**Structural Awareness**	Based on the interview results, it can be seen that student C is able to provide arguments or reasons for the right decision that has been made.

From Table 3, student C lacked focus when reading the problem, so the abstraction process was slow. Although he can sometimes organize chemical symbols and structures, he has difficulty developing new strategies, especially for difficult problems. Abstraction rarely appears, causing concept errors, weak mastery of the material, and difficulty connecting chemical concepts.

The results of the abstraction ability test obtained by student C on low chemical bonding material are in Figures 8, 9, and 10.

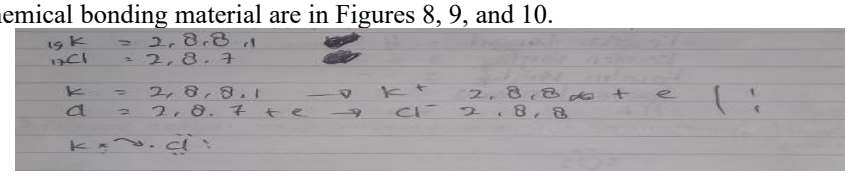

Figure 8. Appendix M3 Easy Category Problem, Describing the Form of the Ion Bond KCl

From Figure 8, it can be seen that student C, struggling with easy category questions, cannot recall previous material related to chemical bonding material and takes a long time to bring up the abstraction process.

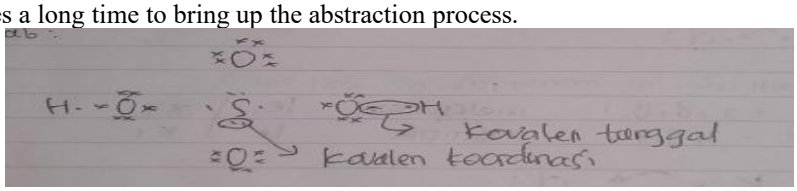

Figure 9. Appendix M3 Medium Category Problem: the type of covalent bond found in the compound H_2SO_4

Figure 9 shows that student C is able to answer and solve chemical bonding problems in the medium category and cannot solve chemical bonding problems. Student C can express the results of his thinking in chemical symbols and chemical structures, such as making electron configurations and Lewis structures.

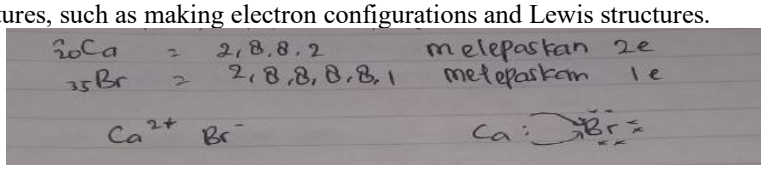

Figure 10. Appendix M3 Hard Category Problem, concluding that the elements Ca and Br compound $CaBr_2$ ions are ionically bonded.

Student C is unable to develop new strategies in solving difficult category questions, making it difficult to correct mistakes that have been made, and is unable to understand and solve problems that develop.

The data description value of chemistry learning outcomes that have been obtained by students can be seen in Figure 11.

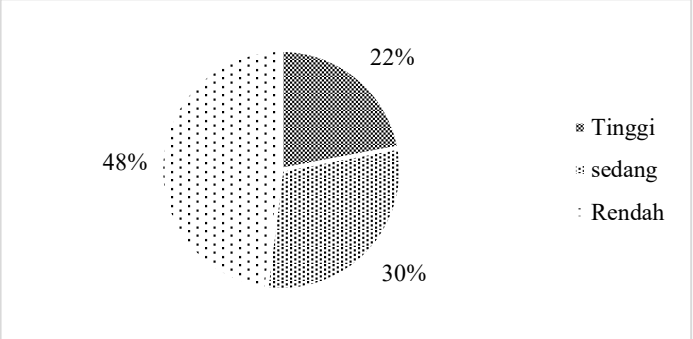

Figure 11. Percentage score of student learning outcomes

In Figure 11. Shows the value obtained by students in learning chemistry reflects the results of semester exams related to chemical bonding material and the abstraction ability of students in class X IPA 2 Madrasah Aliyah Negeri 2 Kampar. To analyze the relationship between chemical abstraction ability and learning outcomes of students in class X IPA 2 Madrasah Aliyah Negeri 2 Kampar, the PASW statistic18 program was used. Before conducting a correlation analysis using the PASW statistic18 program, the relationship between the categories and test scores of chemical abstraction ability and the value of student learning outcomes can be categorized in Table 4.

Table 4. Classification of the relationship between chemical abstraction ability and student learning outcomes

No	Abstraction Ability	Learning outcomes	Frequency	Percentage
1	High	High	5	21.8%
2	High	Medium	0	0%
3	High	Low	0	0%
4	Medium	High	2	8.7%
5	Medium	Medium	5	21.8%
6	Medium	Low	0	0%
7	Low	High	0	0%
8	Low	Medium	9	39%
9	Low	Low	2	8.7%
	Amount		**23**	**100%**

From the explanation of Table 4 above, it can be concluded that between the ability of chemical abstraction and student learning outcomes, there are students who have high abstraction ability scores and high learning outcomes, students who have moderate chemical abstraction ability scores and moderate learning outcomes, and students who have low chemical abstraction ability scores and low learning outcomes. Besides that, there are also students who have moderate abstraction ability scores that allow them to have learning outcomes in the high category and students who have low abstraction ability scores that allow them to have learning outcomes in the medium category. Then the abstraction ability with learning outcomes is sought for a significant relationship.

This hypothesis testing is to determine the relationship between students' abstraction ability and the learning outcomes of students in class X IPA 2 Madrasah Aliyah Negeri 2 Kampar. The hypotheses in this study are

Ha: There is a significant relationship between chemical abstraction ability and student learning outcomes on chemical bonding material in class X IPA 2 Madrasah Aliyah Negeri 2 Kampar.

H_0: There is no significant relationship between chemical abstraction ability and student learning outcomes on chemical bonding material in class X IPA 2 Madrasah Aliyah Negeri 2 Kampar.

To find out if there is a significant relationship between the ability of chemical abstraction and the learning outcomes of students in class X IPA 2 at Madrasah Aliyah Negeri 2 Kampar. Then, the existing data was analyzed first with the help of the PASW Statistics 18 program to test the significant relationship between chemical abstraction ability and student learning outcomes. Hypothesis testing is obtained based on Table 5.

Table 5. Correlation between chemical abstraction ability and student learning outcomes

		Chemistry Value Chemical Abstraction	Student Learning Outcome Score
Chemical Abstraction Ability	Pearson Correlation	1	.708**
	Sig. (2-tailed)		.000
	N	23	23
Student Learning Outcomes	Pearson Correlation	.708**	1
	Sig. (2-tailed)	.000	
	N	23	23

** Correlation is significant at the 0.01 level (2-tailed)

Table 5 shows that the correlation result of 0.708 shows a strong relationship between chemical abstraction ability and student learning outcomes. This relationship can be explained through Piaget's cognitive learning theory, which states that students with formal-operational thinking skills are better able to understand abstract concepts in chemistry. The abstraction process allows students to connect theory with its application, so they more easily understand chemical bonding material and do well on problems. In addition, Vygotsky's theory of constructivism emphasizes the importance of social interaction in building understanding. Students with high abstraction may be more active in discussions and concept exploration, which supports better understanding. In contrast, students with low abstraction tend to have difficulty connecting abstract concepts with real representations, which results in lower learning outcomes.

Compared to previous research, this result is in line with the study of Pratama et al., (2023), who found that chemical abstraction contributed positively to students' concept understanding. However, other studies, such as by Rusandi & Muhammad Rusli (2021), showed that experiment-based interventions can improve students' abstraction, which was initially low. This comparison indicates that in addition to internal factors such as students' abstraction level, learning strategies also affect chemistry learning outcomes.

CONCLUSIONS

The results showed a significant and strong relationship (rxy = 0.708) between chemical abstraction ability and student learning outcomes in chemical bonding material. Students with high abstraction ability are able to understand

concepts better, while students with low ability have difficulty in solving complex problems. The main factors affecting low abstraction ability are the abstract nature of the material, limited understanding of the questions, and low critical and logical thinking skills. More effective learning strategies are needed to improve students' abstraction skills, such as the use of visual media (animation/simulation), inquiry-based approaches, and the integration of macroscopic, microscopic, and symbolic representations in chemistry learning.

Further research recommendations should develop and test innovative learning models that improve abstraction skills. Other factors that affect learning outcomes, such as motivation and thinking strategies, explore the use of technology such as augmented reality (AR) in understanding abstract chemical concepts. This research is expected to be a reference in improving the effectiveness of chemistry learning, especially in understanding abstract concepts.

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