Vol 14 (3), 2025, 112-122 DOI: 10.23960/jppkv2.14310
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-**ISSN 2302-1772**
https://jpk.fkip.unila.ac.id/v2/index

Analysis of Student's Critical Thinking Skills in Solving High Order Thinking Skill Problems on Atomic Structure Material

Yanti Denia, Maefa Eka Haryani*

Chemistry Education, Faculty of Teacher Training and Education, Sriwijaya University
Jl. Raya Palembang-Prabumulih Indralaya Ogan Ilir, Sumatera Selatan Indonesia.

Correspondinge-mail: maefa_eka_haryani@fkip.unsri.ac.id

Received: December 20th, 2025 Accepted: December 30th, 2025 Online Published: December 31th, 2025

Abstract: Analysis of Student's Critical Thinking Skills In Solving High Order Thinking Skill (HOTS) Problems On Atomic Structure Material. 21century education demands mastery of critical thinking skills as part of higher order thinking abilities. The Merdeka Curriculum was introduced to address these demands however, students' critical thinking skills in solving Higher Order Thinking Skills (HOTS) problems have not yet been comprehensively measured. This study aims to analyze students' critical thinking skills in solving HOTS problems on atomic structure topics. This research employed a mixed-methods approach with a QUAN-Qual design. Data were collected through HOTS based cognitive tests and interviews. The analysis of critical thinking skills was based on Facione's indicators, including interpretation, analysis, evaluation, and inference. The results showed that students' critical thinking skills reached 62% (good) for interpretation, 61% (good) for analysis, 59% (moderate) for evaluation, and 64% (good) for inference. These findings indicate that students' critical thinking skills are generally at a good level; however, improvement is still needed, particularly in the evaluation aspect, through more innovative and HOTS-oriented learning approaches.

Keywords: Critical Thinking, Atomic Structure, HOTS

Abstrak:Analisis Kemampuan Berpikir Kritis Siswa dalam Penyelesaian Soal* High Order Thinking Skill (*HOTS) Pada Materi Struktur Atom. *Pendidikan abad ke-21 menuntut penguasaan kemampuan berpikir kritis sebagai bagian dari keterampilan berpikir tingkat tinggi. Kurikulum Merdeka hadir untuk menjawab tuntutan tersebut, namun kemampuan berpikir kritis siswa dalam menyelesaikan soal HOTS belum sepenuhnya terukur secara menyeluruh. Penelitian ini bertujuan untuk menganalisis kemampuan berpikir kritis siswa dalam menyelesaikan soal HOTS pada materi struktur atom. Metode penelitian ini menggunakan metode campuran dengan desain QUAN-Qual. Pengumpulan data dilakukan dengan tes kognitif berbasis HOTS dan wawancara. Analisis kemampuan berpikir kritis didasarkan pada indikator Facione yang meliputi interpretasi, analisis, evaluasi, dan inferensi. Hasil penelitian menunjukkan bahwa kemampuan berpikir kritis siswa pada indikator interpretasi sebesar 62% (baik), analisis 61% (baik), evaluasi 59% (cukup), dan inferensi 64% (baik). Hasil ini menunjukkan bahwa kemampuan berpikir kritis siswa tergolong baik, namun masih perlu ditingkatkan terutama pada aspek evaluasi melalui pembelajaran yang lebih inovatif dan berorientasi HOTS.*

Kata kunci: *Berpikir Kritis, Struktur Atom, HOTS*

INTRODUCTION

21st century learning is a response to the development of globalization and technological anvances that require education to prepare students to have relevant life skills, not only focusing on academic aspects, but also on strengthening critical thinking,

communication, creativity, collaboration, and digital literacy skills (Rosnaeni, 2021). In line with this, the Independent Curriculum emphasizes the development of critical thinking, communication, creativity, collaboration, and digital literacy skills as preparation for facing real demands in society (Mardiana & Emmiyati, 2024). Learning materials are one of the factors affecting the quality of teaching and students' learning outcomes in chemistry education, as they serve as a guide for teachers and students during the learning process (Makharany Dalimunthe et al., 2025).

Critical thinking skills are demonstrated through students' abilities to examine information in depth, weigh various points of view, and make decisions based on logical reasons (Mardiana & Emmiyati, 2024). This study adopts Facione's (2018) critical thinking framework, as it is considered comprehensive in assessing students' higher order thinking skills. Four indicators are employed interpretation, analysis, evaluation, and inference while explanation and self-regulation are represented through the inference stage as the culmination of the critical thinking process. Therefore, Facione's indicators are deemed relevant for analyzing students' critical thinking abilities in solving HOTS questions on atomic structure (Veni Pebrina, 2025).

Higher Order Thinking Skills (HOTS) emphasize individuals' ability to think critically and creatively and to generate innovative solutions through logical and structured problem-solving processes (Sahat Hasiolan Pakpahan, 2021). Accordingly, HOTS questions are designed to assess students' abilities to transfer and apply conceptual knowledge, process and integrate information from multiple sources, solve problems, and critically evaluate ideas (Maya Nurjanah et el., 2021).

Critical thinking skills are essential skills that need to be instilled from an early age through continuous practice, as they relate not only to cognitive aspects but also to attitudes and reflective and rational thinking skills (Kollo & Suciptaningsih, 2024). However, the development of these skills has not been optimal due to conventional assessment practices that are not fully aligned with required competencies, resulting in low student motivation to develop critical thinking (Nadhiroh & Anshori, 2023). In this regard, the Independent Curriculum opens up opportunities for learning innovation by positioning teachers as active mentors who encourage students to explore knowledge, express opinions openly, and learn collaboratively, thereby fostering critical thinking skills more effectively (Alifa Nurmalia et al., 2025).

Based on initial observations at SMAN 2 Indralaya Utara, students experienced difficulty solving HOTS problems on atomic structure, particularly in analyzing phenomena presented in discourse. This was reinforced by an average daily test score of 67.9, indicating that students' critical thinking skills were not yet optimally developed. However, these students' critical thinking skills had never been systematically tested comprehensively. The abstract and conceptual nature of atomic structure requires learning and assessment approaches that foster higher-order thinking skills (Pratiwi et al., 2022), thus revealing a gap between curriculum demands and students' critical thinking abilities. Critical thinking skills are, in fact, a crucial competency that supports conceptual understanding, problem analysis, application of knowledge, and student academic success (Ariadila Salsa et al., 2023).

Based on the problems that have been described, research is needed to examine in depth the critical thinking skills of students in solving HOTS problems on atomic structure material. This study is important to provide a real picture of students' critical thinking skills, as well as being the basis for formulating the problem formulation and

research objectives that focus on analyzing students' critical thinking skills in solving HOTS problems on atomic structure material.

Despite the problems mentioned above, no comprehensive assessment of students' critical thinking skills using Facione's indicators on atomic structure has been conducted in the context of SMAN 2 Indralaya Utara. Based on this gap, the research problem is How are students' critical thinking skills in solving HOTS (Higher Order Thinking Skills) questions on atomic structure? Accordingly, the objective of this study is to analyze students' critical thinking skills in solving HOTS questions on atomic structure.

METHOD

This study employs a descriptive mixed-methods design (QUAN–Qual) to integrate quantitative and qualitative approaches and obtain a more comprehensive understanding of the research problem (Sukaryawan & Sari, 2023). This research was conducted in class XI of SMA Negeri 2 Indralaya Utara, Ogan Ilir Regency, South Sumatra in the odd semester of the 2025/2026. The research participants consisted of 30 eleventh-grade students from SMA Negeri 2 Indralaya Utara, selected through purposive sampling in consultation with the chemistry teacher to ensure relevance to the atomic structure topic.

This study employed quantitative and qualitative instruments. The quantitative instrument consisted of eight HOTS-based essay questions developed by Veni Pebrina (2025) and categorized according to Facione's indicators. The qualitative instrument involved interview guidelines used to collect preliminary data from the chemistry teacher and to explore students' thinking processes and difficulties in solving HOTS questions. The test instrument was empirically validated and tested for reliability using SPSS version 27. Results showed that 80% of the items were valid, and the test demonstrated good internal consistency (Cronbach's Alpha = 0.705), indicating that the instrument reliably measures students' critical thinking skills. The essay questions were categorized according to Facione's indicators: two questions for interpretation (1 and 4), two for analysis (3 and 6), two for evaluation (5 and 7), and two for inference (2 and 8).

Interview data were analyzed using a systematic qualitative approach, following the stages of data reduction, data display, and conclusion drawing. In the data reduction stage, the transcribed interviews were summarized and relevant segments related to students' problem-solving strategies, difficulties, and learning strategies were selected. During the data display stage, the information was organized in tables and narrative summaries according to Facione's indicators to facilitate pattern identification. Finally, in the conclusion drawing stage, patterns and themes were interpreted and triangulated with quantitative test results to provide comprehensive insights into students' critical thinking skills.

This study employed two data collection techniques a written test for quantitative data and interviews for qualitative data. The written test consisted of eight HOTS-based essay questions on electron configuration, representing cognitive levels C4, C5, and C6 and categorized according to Facione's indicators. In addition, structured interviews were conducted during the preliminary study to identify research issues, with responses recorded and documented using interview sheets.

The written test consisted of eight HOTS-based essay questions on electron configuration, covering various indicators of critical thinking according to Facione. Two questions (1 and 4) measured the interpretation indicator, addressing topics such as differences between atomic models and between isotopes, isobars, and isotones. Two questions (3 and 6) measured the analysis indicator, focusing on the comparison of

protons, electrons, and neutrons, as well as the relationship between electron configuration and element position in the periodic table. Two questions (5 and 7) targeted the evaluation indicator, discussing electron configurations in quantum mechanical atomic models and the relationship between electron affinity of alkali and halogen groups. Finally, two questions (2 and 8) measured the inference indicator, dealing with the limitations of Dalton's atomic theory and the relationship between atomic radius and ionization energy. In addition, structured interviews were conducted with three students using the same set of questions. The interview questions included: (1) strategies they used to solve the test questions, (2) difficulties they encountered while answering the questions, and (3) learning strategies that might support the development of their critical thinking skills. Relevant excerpts of the interview questions were presented to illustrate the instruments used.

Research Procedure

The research procedures consisted of three stages: preparation, implementation, and final analysis. The preparation stage involved analyzing learning outcomes in accordance with the Merdeka Curriculum, reviewing literature on critical thinking skills, conducting classroom observations and preliminary interviews with the chemistry teacher, preparing interview guidelines, selecting validated HOTS instruments on atomic structure, and obtaining research permission. The implementation stage included administering validated HOTS-based essay questions to students, documenting the test process, collecting students' responses, and conducting follow-up interviews based on test result categories to explore students' thinking processes and learning difficulties. The final stage involved scoring and assessing students' responses using a rubric, calculating overall scores, and categorizing students' critical thinking abilities based on Facione's indicators in solving HOTS questions on atomic structure.

Data Analysis

Test data were analyzed using descriptive statistics, including the calculation of the mean, percentage, maximum and minimum scores, and standard deviation. Students' scores from HOTS questions on atomic structure were collected, calculated for each indicator, and converted into percentages based on the maximum possible score using the following formula (Akhmad Labib An Naufal & Sari, 2022).

$$Nilai\ Perolehan\ (\%) = \frac{Jumlah\ Skor\ Perolehan}{Skor\ Maksimal} \times 100\%$$

The analysis results were interpreted to draw conclusions about students' critical thinking abilities in solving HOTS questions on atomic structure and were classified according to the scoring criteria presented in Table 1.

Table 1. Criteria for Students' Critical Thinking Ability Levels

Persentage (%)	Category
0-20	Very low
21-40	Low
41-60	Moderate
61-80	Good
81-100	Very Good

Sumber : (Lestari & Lessa Roesdiana, 2021)

Interview data analysis was carried out by transcribing the interview results on an interview sheet by playing the audio recording of the interview results, written using appropriate and easy to understand language rules.

RESULT AND DISCUSSION

The research data are presented in tables and graphs. Table 2 indicates that students' HOTS scores ranged from 7 to 19, with an average score of 14.77 out of a maximum of 24. Figure 9 presents the distribution of percentage scores: two students scored 0–40, five students scored 41–55, sixteen students scored 56–70, and seven students scored 71–85. No students achieved scores in the 86–100 range, indicating that none were able to answer all test items correctly. Therefore, students' cognitive test results on atomic structure based on HOTS are descriptively summarized in Table 2.

Table 2. Average HOTS Score of Students

Descriptive Statistics

	N Statistic	Range Statistic	Minimum Statistic	Maximum Statistic	Sum Statistic	Mean Statistic	Mean Std. Error	Std. Deviation Statistic	Variance Statistic
Total	30	12	7	19	443	14.77	.495	2.712	7.357
Valid N (listwise)	30								

The test consisted of eight HOTS-based essay questions, each with a maximum score of three, resulting in a total possible score of 24. The results of students' critical thinking ability tests are presented in the following frequency distribution graph.

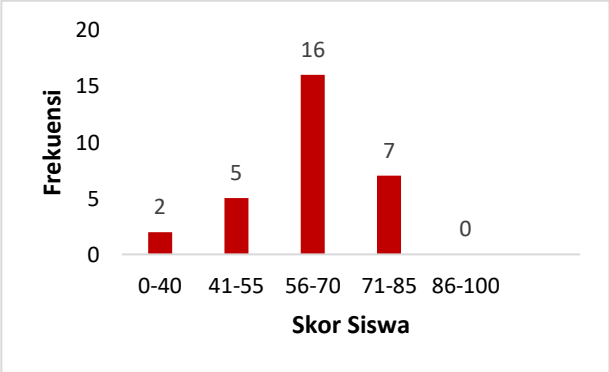

Figure 1. Frequency Distribution Diagram of Students' Critical Thinking Ability Test Results

Based on Figure 9, the frequency distribution shows that most students achieved moderate scores, while only a few obtained low or high scores. This indicates that students generally understand the questions but still experience difficulties in the analysis, evaluation, and inference indicators. This finding aligns with (Facione, 2013) view that critical thinking requires the ability to connect information and provide logical reasoning. Therefore, the graph highlights the need for increased HOTS practice to strengthen students' critical thinking skills.

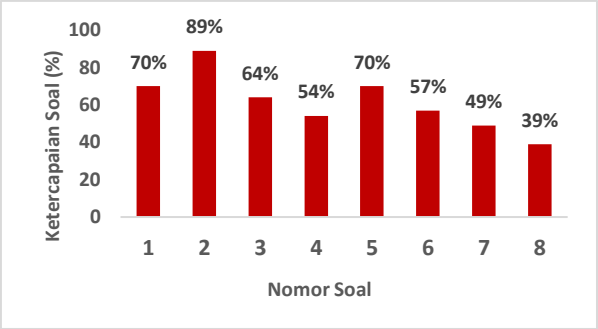

Figure 2. HOTS Achievement Diagram for Each Question Item

Based on Figure 10, the percentages of item achievement vary across the HOTS questions. These percentages represent the ratio between the total score obtained by students on each item and the maximum possible score, where higher percentages indicate better fulfillment of HOTS demands. Question 1, which examined differences between the Thomson and Rutherford atomic models, achieved 70%, indicating that most students were able to analyze the differences effectively. Question 2, related to the limitations of Dalton's atomic theory, showed the highest achievement at 89%, suggesting that students were generally able to draw logical conclusions from the given information. Question 3, concerning protons, electrons, and neutrons, reached 64%, indicating that students could compare these particles to identify isotopes, isotones, and isobars. Question 4, also addressing isotopes, isotones, and isobars, achieved 54%, showing moderate ability, as students still struggled to provide well-reasoned comparisons. Question 5, which focused on electron configuration in the quantum mechanical model, obtained 70%, indicating good understanding of the concept. Question 6, related to the relationship between electron configuration and an element's position in the periodic table, reached 57%, suggesting moderate understanding. Question 7, addressing electron affinity in alkali metals and halogens, achieved 49%, indicating limited ability to connect the concept appropriately. Question 8, which examined the relationship between atomic radius and ionization energy, showed the lowest achievement at 39%, indicating that most students were unable to draw correct conclusions, reflecting low performance in this area.

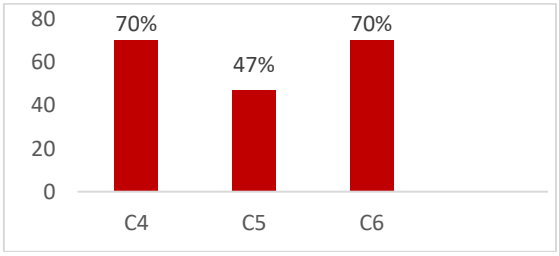

Figure 3. Diagram of Average HOTS Scores Based on Bloom's Taxonomy

Based on Figure 3, the Bloom's Taxonomy cognitive levels show varying student performance. At the C4 level (analyzing), students achieved 70%, which falls into the good category, indicating that they are able to identify required steps and compare different elements in the questions. At the C5 level (evaluating), the achievement was 47%, categorized as moderate, suggesting that students can make decisions in problem solving but still face difficulties in deeper evaluation. At the C6 level (creating), the achievement again reached 70%, indicating that students are relatively more capable of drawing conclusions and providing simple reasoning than performing thorough evaluations. These findings are supported by observations and interviews showing that

students tend to rely on memorized key points when concluding concepts, while they are less trained in evaluating and comparing the strength of arguments. Therefore, although C6 is hierarchically higher than C5, empirical results indicate that evaluation remains the weakest cognitive skill and requires greater emphasis in instruction.

The evaluation indicator achieved the lowest score among the four critical thinking indicators 59% (Moderate). Conceptually, this may be due to the abstract nature of atomic structure concepts, such as electron configuration and electron affinity, which require higher-order reasoning and comparison. Pedagogically, although the school has implemented PBL and HOTS-based questions, students still rely on memorization and have limited exposure to tasks requiring in-depth evaluation. The lack of visual media and contextual examples further constrains students' ability to critically assess and justify their answers. Therefore, enhancing instructional strategies and providing varied HOTS-based practice, including simulations and contextual scenarios, could improve students' evaluative skills.

Analysis of Students' Critical Thinking Skills Based on Facione's Indicators

In this study, four critical thinking indicators were assessed: (1) interpretation, (2) analysis, (3) evaluation, and (4) inference. Figure 4 presents the percentage of students' critical thinking achievement for each indicator.

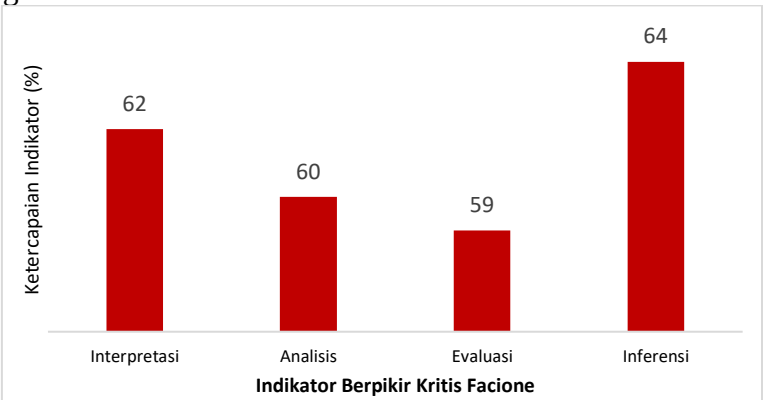

Figure 4. Percentage Diagram of Critical Thinking Achievement Based on Facione's Indicators

Students' critical thinking skills for each indicator were classified into five levels: very low, low, moderate, good, and very good. Of the four indicators assessed, three were categorized as good and one as moderate. The results for each critical thinking indicator are presented in the following table.

Table 2. Categories of Critical Thinking Skills for Each Indicator

Critical Thinking Indicator	Persentage (%)	Category
Interpretation	62	Good
Analysis	61	Good
Evaluation	59	Moderate
Inference	64	Good

The first indicator analyzed in this study was interpretation, which was measured using questions 1 and 4. Interpretation refers to students' ability to understand, express, and explain the meaning of information presented in the questions clearly and accurately (Facione, 2013). This skill involves identifying relevant information and organizing it into logical and context-appropriate responses. The results showed that students demonstrated a good level of interpretation ability, with an achievement percentage of 62%. However, some students still provided unclear or less detailed explanations, indicating that their interpretation skills were not yet fully developed. Overall, the interpretation questions were of moderate difficulty with a one-hour time allocation, allowing most students to achieve good results. This finding is consistent with previous research showing that students who can correctly identify given and required information tend to exhibit stronger critical thinking skills in interpretation (Zahro et al., 2024).

The second indicator assessed was analysis, measured through questions 3 and 6, which required students to relate concepts of protons, electrons, neutrons, electron configuration, and an element's position in the periodic table. The analysis indicator refers to students' ability to determine and describe appropriate solution steps based on the information provided and the demands of the question (Veni Pebrina, 2025). The results showed an achievement percentage of 61%, categorized as good, indicating that most students were able to write solution steps in accordance with the concepts and information given. However, some students still struggled to apply the correct procedures consistently. This finding is consistent with previous studies showing that students generally demonstrate good analytical skills but require more structured instruction and continuous practice to further develop them (Musahrain et al., 2024). Regular exposure to varied reasoning-based exercises is expected to support the improvement of students' analytical abilities.

The third indicator assessed was evaluation. Questions 5 and 7 required students to solve electron configuration problems, determine valence electrons, and relate electron affinity in halogen and alkali elements. The evaluation indicator refers to students' ability to present solutions in a systematic and logical manner and to judge the correctness of their answers based on previously learned concepts before drawing appropriate conclusions (Veni Pebrina, 2025). The data analysis showed an achievement percentage of 59%, categorized as fair. This indicates that students were fairly able to write logical solutions and provide arguments for their answers. This finding is consistent with previous research stating that students are able to critically distinguish between strong and weak arguments (Widiastuti & Hamidi, 2025). However, the achievement level in the fair category suggests that some students were not consistent in giving complete and in-depth explanations. Classroom observations also showed that students often wrote only the final answer without detailed reasoning and still relied on memorizing concepts, which limited the development of their evaluation skills.

The fourth indicator was inference. In questions 2 and 8, students were required to draw logical conclusions, including identifying the limitations of Dalton's atomic theory and relating atomic radius to ionization energy. The inference indicator refers to students' ability to draw logical conclusions based on the information and facts provided in the questions and to connect relevant concepts to produce appropriate and justified conclusions (Veni Pebrina, 2025). The data analysis showed an achievement percentage of 64%, which falls into the good category. This indicates that students were generally able to answer the questions using relevant information. This finding is consistent with previous research showing that students are able to evaluate the validity of information

by considering the evidence provided (Widiastuti & Hamidi, 2025). Classroom observations also revealed that students were accustomed to working on questions that require reasoning and simple justification during discussions and practice activities. As a result, they were relatively able to assess the correctness of information, although their explanations were not always in-depth.

This study is consistent with previous research showing that students' critical thinking achievement on the inference indicator tends to be higher than on the interpretation indicator, because students find it easier to draw conclusions than to explain the initial context in detail (Shafira et al., 2023). In addition, the results align with findings that the evaluation indicator is in the fair category, while the other indicators are in the good category (Faradisa et al., 2022). Therefore, although the critical thinking ability of Grade XI.1 students at SMA Negeri 2 Indralaya Utara in the 2025/2026 academic year is classified as good, it still needs to be improved so that students can provide deeper reasoning and explanations. This finding is supported by Juwanti (2024) who concluded that students still require the development of critical thinking skills through HOTS-based exercises and learning activities that demand higher-order reasoning. This condition occurs because students are not yet accustomed to working on questions that require deep reasoning, especially HOTS-type questions. Teachers also reported that students' interest in atomic structure material is relatively low, and there are limitations in learning media and facilities, which make it difficult for students to understand abstract concepts such as atomic models, electron configuration, and the relationships among periodic properties.

Overall, students performed moderately on HOTS questions, showing relative strength in inference but weakness in evaluation. This suggests that while students can draw conclusions based on given information, they struggle to critically assess and justify their answers. These findings imply the need for enhanced instructional strategies, such as more HOTS-based practice, visual media for abstract concepts, and activities that strengthen evaluative reasoning in chemistry learning. Instruction primarily relies on teacher-centered lectures and discussions, providing limited opportunities for students to actively analyze, evaluate, and justify their answers, which may explain their relative weakness in the evaluation indicator of HOTS questions (Zain & Pulungan, 2025).

Interview Results

Based on interviews with the chemistry teacher at SMA Negeri 2 Indralaya Utara, the school has implemented the Merdeka Curriculum (deep learning). The learning process already applies Higher Order Thinking Skills (HOTS) through the Problem Based Learning (PBL) model, where students are given problem-based scenarios to be analyzed in groups and HOTS-based questions are used for evaluation. However, this approach has not fully supported all aspects of students' critical thinking skills. Therefore, teachers still need to improve the learning process, especially by strengthening learning models and increasing students' exposure to HOTS-based questions.

Interviews were also conducted with three students selected based on high, medium, and low test scores. According to these students, HOTS questions on atomic structure were considered moderate to difficult. They tended to write down key points and memorize them. Students also reported difficulty understanding the material when it was explained without learning media. Although the teacher had used problem-based learning with contextual scenarios, students found the material easier to understand when visual media were used, such as simulations or educational websites. In addition, students experienced difficulties in solving electron configuration problems that involve

calculations, including determining electron configurations and the number of protons, electrons, and neutrons. They also found it difficult to answer questions comparing atomic theories because it was hard to distinguish between different atomic models.

CONCLUSION

Based on the research results, it can be concluded that students' critical thinking skills in solving HOTS questions on the topic of Atomic Structure at SMA Negeri 2 Indralaya Utara are in the good category. This is shown by the achievement percentages of the critical thinking indicators: interpretation (62%), analysis (61%), evaluation (59%), and inference (64%).These results indicate that students' critical thinking skills still need improvement. The lower achievement in some indicators may be caused by students' difficulty in providing accurate and complete answers, as well as learning processes that focus more on memorization and do not fully support the development of critical thinking skills. Therefore, more innovative and meaningful learning strategies are needed to continuously encourage students to practice and develop their critical thinking skills.

Furthermore, this study contributes to the development of HOTS-based assessment instruments for atomic structure topics, providing a validated and reliable reference for teachers and researchers. It also offers practical implications for chemistry learning, emphasizing the need for instructional strategies that foster critical thinking, such as problem-based learning, contextual scenarios, and the use of visual media to help students better understand abstract concepts.

REFERENCES

Akhmad Labib An Naufal, & Sari, I. K. (2022). Pengembangan E-Book Matematika Untuk Meningkatkan Keterampilan Berpikir Kritis Siswa Pada Materi Persamaan Garis Lurus. *MATHEdunesa*, *11*(2), 378–389.

Alifa Nurmalia, S., Meliani, A., Fauzi Rachman, I., & Siliwangi, U. (2025). Peran Kurikulum Merdeka dalam Mendorong Critical Thinking melalui Pembelajaran Kontekstual. *Jurnal Penelitian Pendidikan Indonesia*, *2*(4), 233–242.

Ariadila Salsa, Silalahi Yessi, Fadiyah Firda, Jamaludin Ujang, & Setiawan Sigit. (2023). Analisis Pentingnya Keterampilan Berpikir Kritis TerhadapPembelajaran Bagi Siswa. *Jurnal Ilmiah Wahana Pendidikan*, *9*(20), 664–669.

Facione, P. A. (2013). *Critical Thinking : What It Is and Why It Counts*. California: Insight Assesment.

Faradisa, A. P., Utami, R. E., & Aini, A. N. (2022). *Analisis Kemampuan Berpikir Kritis Siswa dalam Menyelesaikan Soal Tipe HOTS Ditinjau dari Pemecahan Masalah*. *07*(02), 27–45.

Juwanti, R. R. (2024). *Analisis Berpikir Kritis Peserta Didik Dalam Menyelesaikan Soal HOTS Materi Struktur Atom-Periodik Unsur*. Skripsi. Palembang: Universitas Sriwijaya.

Kollo, N., & Suciptaningsih, O. A. (2024). Keterampilan Berpikir Kritis Siswa melalui Penerapan Kurikulum Merdeka. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *7*(2), 1452–

Lestari, S. Z. D., & Lessa Roesdiana. (2021). ANALISIS KEMAMPUAN BERPIKIR KRITIS MATEMATIS SISWA SMP PADA MATERI HIMPUNAN. *JPMI (Jurnal Pembelajaran Matematika Inovatif)*, *8*(1), 559.

Makharany Dalimunthe, Sugiharti, G., Amdayani, S., & Siregar, M. I. (2025). Efektivitas Modul Elektronik Elektrokimia Berbasis STEM dalam Meningkatkan Keterampilan

Berpikir Kritis. *Jurnal Pendidikan dan Pembelajaran Kimia*, *14*(1), 70–76.

Mardiana, & Emmiyati. (2024). IMPLEMENTASI KURIKULUM MERDEKA DALAM PEMBELAJARAN: EVALUASI DAN PEMBARUAN. *Jurnal Kajian Pendidikan dan Hasil Penelitian*, *10*(2), 121–127.

Maya Nurjanah, Fauzia, F., & Fatonah, S. (2021). Implementasi Lots Dan Hots Pada Soal Tema 3 Kelas 1 Mi/Sd. *Jurnal Evaluasi dan Pembelajaran*, *3*(2), 70–79.

Musahrain, Ainurrahmi, Ferniawan, & Ainun Sabrina. (2024). Analisis Kemampuan Berpikir Kritis Pada Mata Pelajaran IPA SMP Kelas IX Di Kabupaten Sumbawa. *Jurnal Pendidikan dan Pembelajaran Kimia*, *05*(02), 152–159.

Nadhiroh, S., & Anshori, I. (2023). Implementasi Kurikulum Merdeka Belajar dalam Pengembangan Kemampuan Berpikir Kritis pada Pembelajaran Pendidikan Agama Islam. *Fitrah: Journal of Islamic Education*, *4*(1), 56–68.

Pratiwi, S. A., Sudyana, I. N., & Fatah, A. H. (2022). Pengembangan media pembelajaran digital berbasis articulate-storyline-3 pada pokok bahasan struktur atom. *Journal of Environment and Management*, *3*(2), 153–160.

Rosnaeni. (2021). Karakteristik dan Asesmen Pembelajaran Abad 21. *Jurnal Basicedu*, *5*(5), 5(5), 524–532.

Sahat Hasiolan Pakpahan. (2021). *TIPS MEMBUAT SOAL HOTS IPA SMP dan FISIKA SMA*. Indonesia: GuePedia.

Shafira, A., Muchtadi, & Nurmaningsih. (2023). *ANALISIS KEMAMPUAN BERPIKIR KRITIS SISWA DALAM MENYELESAIKAN SOAL HIGHER ORDER THINKING SKILL (HOTS)*. *2*(6), 1884–1888.

Sukaryawan, M., & Sari, D. K. (2023). *Buku Ajar Penelitian Pendidikan Berbasis Konstruktivisme Fhase Nedham*. Palembang: Bening Media Publisher.

Veni Pebrina. (2025). PENGARUH PENERAPAN MODEL PEMBELAJARAN DISCOVERY LEARNING TERHADAP KEMAMPUAN BERPIKIR KRITIS PESERTA DIDIK PADA MATERI STRUKTUR ATOM DAN SISTEM PERIODIK UNSUR. *UNIVERSITAS ISLAM NEGERI SULTAN SYARIF KASIM RIAU*, *11*(1), 1–14. Skripsi. Riau: UIN SUSKA.

Widiastuti, M., & Hamidi, N. (2025). Analisis Keterampilan Berpikir Kritis Siswa Sekolah Menengah Kejuruan Menggunakan Tes W-GCTA. *Jurnal Pendidikan Akuntansi Indonesia*, *23*(02), 22–36.

Zahro, S. M., Susanto, & Siwito, A. (2024). Analisis Kemampuan Berpikir Kritis Siswa Kelas XII Di Jember Pada Materi Dimensi Tiga. *Jurnal Inovasi Pendidikan Menengah*, *4*(2), 55–60.

Zain, Z. R., & Pulungan, hmad N. (2025). Pengembangan Lembar Kerja Elektronik Siswa (E-LKPD) Berbasis Pembelajaran Berbasis Masalah untuk Meningkatkan Hasil Belajar Siswa pada Materi Laju Reaksi. *Jurnal Pendidikan dan Pembelajaran Kimia*, *14*(1), 58–69.