Development of Baper Bolu as a Chemistry Learning Media Based On Adiwiyata

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Abstract

Higher Order Thinking Skills is one of the skills necessary in the 21st Century. So, learning media are required to improve students’ higher-order thinking skills. Chemistry textbooks used as learning media should contain questions that will enhance students' thinking processes, especially higher-order thinking skills (HOTS). However, there are no criteria for assessing the questions in the textbook, especially for higher-order thinking questions. This study aims to determine the HOTS aspect using the Brookhart category on questions in the XII grade chemistry textbook. The research method used is the descriptive method of document analysis. The results showed that the average percentage of HOTS questions in the three class XII chemistry textbooks was 25.95%, covering aspects of analyzing 8.85%, creating 3.51%, reasoning and logic 8.35%, problem-solving 3.71%, and creative thinking 1.53%. Meanwhile, the aspects of evaluating and making decisions are not present in each analyzed chemistry textbook. Based on the research results, it can be seen that questions of low-level thinking skills still dominate the chemistry textbook for class XII.

Keywords: chemistry textbooks; higher-order thinking skills; HOTS; question

Abstrak

Keterampilan berpikir tingkat tinggi merupakan satu di antara keterampilan yang dibutuhkan pada abad 21, untuk itu diperlukan media pembelajaran yang dapat meningkatkan kemampuan berpikir tingkat tinggi peserta didik. Buku teks kimia yang digunakan sebagai media pembelajaran sudah seharusnya berisi pertanyaan yang meningkatkan proses berpikir peserta didik, terutama keterampilan berpikir tingkat tinggi (HOTS). Namun, belum ada kriteria untuk menilai pertanyaan yang ada pada buku teks, khususnya untuk pertanyaan berpikir tingkat tinggi. Penelitian ini bertujuan untuk mengetahui aspek HOTS menggunakan kategori Brookhart pada pertanyaan yang terdapat dalam buku teks kimia kelas XII. Metode penelitian yang digunakan berupa metode deskriptif jenis analisis dokumen. Hasil penelitian menunjukkan rata-rata persentase pertanyaan HOTS ketiga buku teks kimia kelas XII sebesar 25,95%, meliputi aspek menganalisis 8,85%, mencipta 3,51%, penalaran dan logika 8,35%, pemecahan masalah 3,71%, dan berpikir kreatif 1,53%. Sementara aspek mengevaluasi dan mengambil keputusan tidak terdapat pada masing-masing buku teks kimia yang dianalisis. Berdasarkan hasil penelitian, dapat diketahui bahwa buku teks kimia kelas XII masih didominasi pertanyaan keterampilan berpikir tingkat rendah.

Kata kunci: buku teks kimia; keterampilan berpikir tingkat tinggi; HOTS; pertanyaan

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Introduction

Higher-order thinking skills are one of the skills needed in the 21st Century. Therefore, an education that can develop higher thinking skills for students is required. In Indonesia, this is adopted by the 2013 Curriculum of “4K” (4C), which consists of (a) critical thinking and problem solving, (b) communication skills, (c) creativity and innovation, and (d) collaboration. These four 21st century skills can be achieved if they are supported by learning oriented to the development of HOTS (Nofrion & Wijayanto, 2018). Brookhart (2010) classifies Higher Order Thinking Skills (HOTS) into seven skills: analyzing, evaluating, creating, reasoning and logic, decision making, problem-solving, and creative thinking.

Based on PISA 2018 (Program for International Students Assessment) results, Indonesia's scientific ability is ranked 71 out of 79 countries (Schleicher, 2019). It shows that Indonesia is still at a low level of thinking. Students can use the knowledge of content and primary or day-to-day procedures to recognize or identify the explanations of simple scientific phenomena. However, students can only identify causal or correlation relationships and interpret graphic and visual data, which require cognitive skills at a lower level (Suprayitno, 2019). Meanwhile, the learning process in countries with high PISA scores prioritizes high-level reasoning processes, which causes changes in the learning process and mastery of practice questions dominated by memorization activities for preparation or exam implementation activities (Pratama & Retnawati, 2018). Therefore, synergies of teaching, learning, and HOTS-oriented assessment are needed to develop students’ higher-order thinking skills in Indonesia.

Based on Permendikbud (Regulation of Ministry of Education & Culture) Number 22 of 2016 concerning Standards of Learning Process in Elementary & Secondary, consisted of planning, implementation, and assessment, a learning plan consists of formulating a learning implementation plan (RPP), selecting media and learning resources, preparing learning assessment tools and learning scenarios that will be used at the learning implementation stage. Textbooks are one learning media that can be used at the learning implementation stage. According to Damanik & Zainil (2019), textbooks are tools in teaching and learning. It is reinforced by a survey in 12 South Tangerang City Senior High Schools, where all schools use textbooks as learning media. Seven different types of books were obtained from one school to another. In supporting the learning of the 2013 curriculum implementing 21st-century skills, it is necessary to harmonize the textbooks used in the learning process (Rizqiana et al., 2019).

Before being used in learning activities, textbooks must go through a feasibility test conducted by the National Education Standards Agency (BSNP) and stipulated through a ministerial regulation (Rahmawati, 2015). There are four components of the assessment by BSNP, namely: content, presentation, language, and graphics. One of the assessments on the presentation component is assessing the existence of practice questions that can measure students' understanding of the material presented in the textbook. However, in the presentation component assessment items, it is not explained how the criteria should be for the questions in the textbook, especially questions for higher-order thinking skills.

A good textbook is a textbook that meets the needs of learners in all domains, such as remembering, understanding, applying, analyzing, evaluating, and creating. Questions that train higher-order thinking skills (analyze, evaluate, and create) should be included in the textbook (Abdelrahman, 2014). Questions in science textbooks, such as chemistry, must facilitate and improve students' thinking processes and encourage students to work independently (Upahi & Jimoh, 2016).

Based on the interview results with chemistry teachers, it was found that the material on Colligative Properties of Solutions and Redox and Electrochemistry was considered to require high-level thinking skills. In line with the research
conducted by Haryani et al. (2014), which stated that the material of Colligative Properties of Solutions as well as Redox and Electrochemistry was considered difficult by teachers and prospective chemistry teachers because the material was abstract, and there were applications of concepts into calculations. Based on the background explained, the researcher is interested in analyzing the HOTS type questions contained in grade XII chemistry textbooks, especially on the material of Colligative Properties of Solutions and Redox and Electrochemistry.

Research Method

The research design used was a descriptive method of document analysis. In document analysis, research was carried out on the information documented in the recording, either in images, sounds, writings, or others. Document analysis research is also known as content analysis research. In document analysis, researchers described the content of the communication material objectively and systematically with a quantitative approach.

The population of this study was all chemistry textbooks for grade XII used by all State Senior High Schools in South Tangerang City based on the results of interviews. The purposive sampling technique was used to determine the sample of books to be analyzed. Three chemistry textbooks for grade XII were chosen because they were most widely used in state senior high schools of South Tangerang City. Each chemistry textbook was coded A, B, and C, respectively.

Interviews and document studies were used as data collection techniques. Structured interviews were conducted with chemistry teachers in class XII at SMA Negeri Tangerang Selatan regarding using textbooks and materials that require higher-order thinking skills. The next stage was document study. The documents analyzed were in the form of questions existing in the textbooks that have been set as samples. The questions analyzed were existed in the Colligative Properties of Solutions and Redox and Electrochemistry chapters. The questions in the chapter were analyzed based on the aspect of higher-order thinking skills based on Brookhart.

Data analysis techniques were quantitative data and qualitative data. The data analysis technique used to obtain quantitative data was the triangulation technique. Quantitative data obtained in this study were in simple calculations presented in percentage form. Meanwhile, the qualitative data described the results obtained based on quantitative analyses.

Research Result & Discussion

Distribution of Questions in each Chemistry Textbook

Each book has a different distribution of questions, as described in Table 1. The questions in each chemistry textbook are essays and multiple choice. Two chapters were selected to be analyzed in each book, namely the Chapter on Colligative Properties of Solutions and Redox and Electrochemistry. The questions analyzed in each chapter included questions in the exercise, evaluation, practicum, and task sections.

Distribution of each HOTS Aspect according to Brookhart in the three chemistry textbooks

The questions in the three chemistry textbooks for grade XII were based on Brookhart’s HOTS criteria, consisting of seven aspects and divided into several criteria.
Table 1

Distribution of Questions in each Chemistry Textbook

| Book Code | Number of questions in each section | Total |
|-----------|-------------------------------------|-------|
|           | L  | P  | E  | T  |       |
| A         | 198 | 28 | 88 | 2  | 316   |
| B         | 125 | 9  | 148| 4  | 286   |
| C         | 49  | 21 | 62 | 34 | 166   |
| Total     |    |    |    |    | 768   |

Information:
L : Exercise  E : Evaluation
P : Practicum  T : Task

Table 2

Percentage Distribution of HOTS Aspects on Questions in Three Chemistry Textbooks Using Brookhart Categories

| HOTS Aspect        | HOTS Criteria                                | Chemistry Textbook | Total of Each criterion | Average |
|--------------------|----------------------------------------------|--------------------|-------------------------|---------|
| Analyzing          | Focusing on the question or identifying the main idea | A  | B  | C  |                 | 8.85   |
|                    | Analyzing argument                            | 5.70 | 2.45 | 4.22 | 12.37          |
|                    | Comparing and Contrasting                     | 4.11 | 4.54 | 3.61 | 12.26          |
| Evaluating         | Evaluating materials and methods based on the intended purpose | 0  | 0  | 0  | 0               |
| Creating           | Combining different things in a new way       | 1.60 | 0.70 | 1.21 | 3.51          |
| Reasoning & Logic  | Making or evaluating deductive conclusions    | 2.85 | 3.15 | 0.60 | 6.60          |
|                    | Making or evaluating inductive conclusions    | 5.70 | 1.40 | 3.01 | 10.11         |
| Decision Making    | Evaluating the credibility of a source        | 0  | 0  | 0  | 0               |
|                    | Identifying implied assumptions               | 0  | 0  | 0  | 0               |
|                    | Identifying rhetorical and persuasive strategies | 0  | 0  | 0  | 0               |
| Problem Solving    | Identifying and defining problems             | 1.60 | 2.10 | 4.82 | 8.52          |
|                    | Identify inaccuracies to solve the problem    | 0  | 0  | 0  | 0               |
|                    | Describing and evaluating several solution strategies | 0  | 0  | 0  | 0               |
|                    | Creating a model of the problem               | 2.53 | 0.35 | 1.81 | 4.69          |
|                    | Identifying obstacles in solving problems     | 0  | 0  | 0  | 0               |
|                    | Explaining with data                          | 5.40 | 6.30 | 4.82 | 16.52         |
|                    | Utilizing analogy                             | 0  | 0  | 0  | 0               |
|                    | Solving problems in reverse                   | 0  | 0  | 0  | 0               |
| Creative Thinking  | Creative Thinking                             | 032 | 0  | 1.21 | 1.53          |
| Total HOTS Questions |                                            | 25.95             |

From the findings in Table 2, it can be seen that the distribution of HOTS questions in the three textbooks is 25.95%. Each aspect of HOTS obtained a different average, namely: analyzing 8.85%; created 3.51%; reasoning and logic 8.35%; problem-
solving 3.71%; and 1.53% creative thinking. Meanwhile, evaluating and making decisions aspects are not found in each textbook. These results are in line with the research conducted by Upahi & Jimoh (2016) on three chemistry textbooks, which stated that the analysis aspect had an average with the most dominant percentage of 19.5%, while the evaluation aspect of 2.17% and creation aspect of 2.34%.

According to Upahi & Jimoh (2016), the analyzing aspect has a large percentage compared to other aspects of higher-order thinking skills. Analyzing is an intermediate stage of the cognitive process level. In addition, the question of analyzing aspects of the textbook is considered appropriate as an initial question for students for each discipline at the tertiary level. There is a difference in percentage figures in the analytical aspect obtained (8.85%) with the results of previous studies by Upahi & Jimoh (19.5%) and Dávila & Talanquer (30.8%). It is due to differences in the number and part of the questions in the textbook analyzed. In Upahi & Jimoh's research (2016), the questions analyzed were taken from the end of each chapter in each textbook, the results obtained that the most analyzing aspects were at the end of each chapter.

Meanwhile, the analytical aspect obtained in this study has a dominant percentage of 8.85%. The essential competencies of the 2013 curriculum on the material of Colligative Properties of Solutions and Redox and Electrochemistry require analytical skills. It is in line with Abdullah et al. (2018) research, which states that the colligative property of solution material is one of the materials that require higher-order thinking skills because students are asked to analyze, sort, and relate the relationships between concepts on the topic. Research conducted by Damayanti et al. (2019) stated that Redox and Electrochemistry materials also require higher-order thinking skills because, in this material, there are several topics (e.g., electrolysis) that need students to have the skills to analyze the reactions that occur at the anode and cathode and the reaction result.

Criteria for evaluating aspects consist of the ability to identify and assess. At the same time, the decision-making aspect includes criteria to assess and identify. So, it can be concluded that the evaluation aspect is one of the criteria for making decisions (Brookhart, 2010). Anderson & Krathwohl (2001) expressed the same thing, who stated the evaluation aspect as the ability to make decisions based on criteria and standards. The analysis of questions in the three chemistry textbooks showed no question on evaluating and making decisions aspects. There are no essential competencies that require students to assess or make decisions based on criteria and standards. It is in line with research conducted by Zorluoglu et al. (2020) based on the analysis of the chemistry curriculum in textbooks in Turkey, where the percentage of evaluating aspects is 0%.

The description of the HOTS Aspects on the questions of grade XII chemistry textbooks
1. Analyzing

The ability to analyze is when students can break down information and explain its parts. The analyzing aspect consists of three criteria: focusing on questions or identifying the main idea, analyzing arguments, and comparing and contrasting.

a. Focusing on questions or identifying the main idea

The criteria for focusing on questions obtained the most significant percentage, i.e., 12.37%, because this criterion is an essential skill in analyzing in various fields of science. The question above is an example of a question on the criteria of focusing on questions. The question requires students to conduct an experiment and then answer the question based on the results obtained. These questions go through several thought processes by connecting experimental data to conclude and answer questions.
The student's ability to focus on questions can be assessed by asking questions in the form of problems, policies, or experiments and their results, then asking about the main problem in the questions given or asking of what criteria students use to evaluate the quality and truth of an argument or conclusion. Focusing on questions can train students to be more interested in and interpret the learning carried out in learning chemistry. Focusing on questions can improve students' higher-order thinking skills.

b. Analyzing argument

The analyzing argument is the ability to identify underlying assumptions, represent the logic or structure of an argument, find irrelevancies, and assess similarities or differences in two or more arguments. Questions on the criteria for analyzing the argument resulted in a percentage of 12.26%.

The question above is an example of the criteria for analyzing arguments. The question asks students to explain the reasons that support the argument. Students must connect and identify existing events or phenomena with knowledge relevant to the phenomenon. The ability to analyze students' arguments can be assessed by providing an argument, idea, or statement and then asking things that support or contradict the idea, argument, or statement. The ability to argue is a part of making decisions, defending them, and influencing others (Farida, 2014).

c. Comparing and Contrasting

To compare is to determine the relationship between two ideas, two objects, and the like. Distinguishing is the process of sorting out the relevant material from the irrelevant or the important from the unimportant. The criteria for comparing and differentiating obtained a percentage of 1.91% in the three chemistry textbooks.

The question above is an example of comparing and contrasting criteria. The question asks students to compare between two phenomena or events, after which students are asked to distinguish based on these phenomena or events. When there is a process of comparing and contrasting, there will be a shift in attention and focus between relevant and irrelevant material (Rochman & Hartoyo, 2018). According to Setyarini & Ling (2019), exercises are needed to develop higher-order thinking skills that encourage students to compare and differentiate.

2. Creating

The aspect of creating involves arranging elements into a coherent or functional whole. The creative aspect percentage is 3.51% from the three chemistry textbooks analyzed.
**Figure 3**
*Questions on the Criteria of Comparing and Contrasting*

| If pure water and sugar solution are heated respectively, the water as the solvent will evaporate. Guess which liquid evaporates more, pure water or sugar solution? |

(Sutresna et al., 2016: 6)

**Figure 4**
*Questions on Creating Aspect*

| Find in electronic media (internet) or books in the library about how to electrolyze metals (electroplating). Make an experimental design to coat iron metal (nails) with copper metal in groups. Show the teacher the results of the experimental design that your group has made. If it’s approved, do the experiment. Make a report on the results of the experiments carried out. |

(Sudarmo, 2013: 68)

The question above is an example of a question on creating. The question asks students to make a new experimental design by applying the information sought previously, after which students are asked to make a report of the experiment carried out. This question goes through the process of formulating, looking for information about metal plating on objects. Then, it is followed by the planning process, which is making work steps and completion plans in carrying out the metal plating process on objects. The last is the production process, namely making reports from the experimental design of the plating process on objects.

According to Ramadhana et al. (2018), a question raises a plan or suggestion for a case or problem. Students are given a task to draw suggestions based on the problem, including questions or tasks that develop creative abilities.

3. **Reasoning & Logic**

Reasoning and logic abilities are skills to assess whether a fact or claim is accurate and relevant to an argument or problem that occurs and assesses whether two things or events are consistent or not. Questions on reasoning and logic obtained a percentage of 8.35%. Aspects of reason and logic are divided into two, making or evaluating both deductive & inductive conclusions.

a. **Making or evaluating deductive conclusions**

Deductive reasoning can draw specific conclusions from general matters or cases. Questions on the criteria for making or evaluating deductive conclusions have a percentage of 6.60%. The question above is an example of the criteria for making or evaluating deductive conclusions. The question asks students to choose an appropriate statement from a series of choices in the form of a true or false statement based on the data provided. To assess the ability of students to make or evaluate deductive conclusions, the questions or tasks given are in the form of statements that are considered true/false or one or more logical conclusions that are considered true/false, then questions are given which conclusion is in accordance with the statement.

b. **Making or evaluating deductive conclusions**

Inductive reasoning is an action to draw conclusions or make a new general statement based on several specific statements known to be true. Questions on
the criteria for making or evaluating of inductive conclusions obtained a percentage 10.11%.

**Figure 4**
*Questions on Criteria for Making or Evaluating Deductive Conclusions*

| Reaction                     | $E^0$ (volt) |
|------------------------------|--------------|
| Cu$^{2+} + 2e^- \rightarrow$ Cu | +0.34        |
| Sn$^{2+} + 2e^- \rightarrow$ Sn | -0.14        |
| Ni$^{2+} + 2e^- \rightarrow$ Ni | -0.25        |
| Cd$^{2+} + 2e^- \rightarrow$ Cd | -0.40        |

Which of the following statements is true regarding this data?
1. Among the metals above, Cu$^{2+}$ is the strongest oxidizing agent
2. The pair of electrodes that produces the largest cell potential is the Cu with Cd
3. Ni is soluble in Cu$^{2+}$ solution but insoluble in Cd$^{2+}$ solution
4. Among the above metals, Sn is the strongest reducing agent

*(Sudarmo, 2013: 78)*

**Figure 5**
*Questions on Criteria for Making or Evaluating Inductive Conclusions*

*The following figure is a P-T diagram for a pure substance X*

Which of the following statements is true?

a. Q is the critical point of substance X
b. The melting point of substance X increases with an increase in external pressure
c. At point R, the three phases are in equilibrium
d. The boiling point of substance X decreases when the external pressure is increased
e. At point T, solid X is in equilibrium with vapor X

*(Purba, 2016: 37)*

The question above is an example of the criteria for making or evaluating inductive conclusions. The question asks students to choose the correct decision or statement related to the data provided, which is in the form of an image. For this reason, students must understand the meaning of the image given and relate it to the statement. The student’s ability to make or evaluate inductive conclusions can be assessed by asking questions or assignments in the form of scenarios and some information. Then, ask students to draw appropriate conclusions from the information and explain why these conclusions are considered valid.

4. **Problem Solving**

   Problem-solving ability occurs when a person can identify what problems are encountered, what causes the problem cannot be solved, and what solutions can
solve the problem. The percentage of problem-solving aspects in the three chemistry textbooks was 3.71%. There are three criteria for problem-solving abilities in chemistry textbooks: identifying and determining problems, making a model of the problem, and explaining with data.

a. Identifying and defining problems
Identifying and determining problems is the first stage in problem-solving ability. Questions on the criteria to identify and resolve the problem obtained a percentage of 8.52%.

Figure 6
Questions on Criteria Identifying and Defining Problems

| Observe some metal objects around you. Old metal objects will look dull. The electroplating process can be used as a way to make metal objects look beautiful and attractive... |
| Describe the substances needed, the processing steps, and the reactions that occur during the plating process. Find the information needed to know the metal plating process from various reading sources. After that, discuss the information obtained in groups. |

(Sutresna et al., 2016: 37)

The question above is an example of the criteria for identifying and determining problems. The question asks students to identify problems by searching from various reading sources based on events in everyday life. Those questions are examples of open and non-routine questions because there may be more than one answer for students who are asked to seek information from various reading sources. According to Afifah & Retnawati (2018), to instill HOTS values, one strategy that can be done is to compile problems that are not routine or open.

b. Making a model of the problem
Making a model of the problem is one of the stages in problem-solving ability, namely planning a problem-solving. Questions on the criteria for making a problem model obtained a percentage of 4.69%.

Figure 7
Questions on Criteria Create a Model of the Problem

| Draw a diagram of an electrolytic cell for plating iron with silver. Write the electrode reactions and the cell reactions. |

(Sutresna et al., 2016: 89)

The question above asks students to make a diagram or picture of a problem or phenomenon. The students' ability to make a model of the problem can be assessed by asking questions that require students to state the problem in the form of diagrams or pictures that show the situation of the problem. Making an image or model is a strategy in solving problems. This strategy can help clarify the relationship between the data provided and the problems at hand (Ayuningrum, 2017).

c. Explaining with data
The question of explaining with data is 16.52%. The question above asks students to solve the problem by choosing the correct statement based on information in a data table. The student's ability to explain with data can be assessed by asking questions or assignments in interpretive data (graphics or data tables) or other information, then asking students to solve problems and explain procedures based on the data.

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asking students to solve problems and explain procedures based on the data.

**Figure 8**
*Questions on Criteria of Explaining with Data*

The following is the freezing point data (Tb) of various electrolyte and nonelectrolyte solutions.

| Solution | Concentration (m) | Freezing Point (°C) |
|----------|-------------------|---------------------|
| Sugar    | 0.1               | −0.186              |
| Urea     | 0.2               | −0.372              |
| NaCl     | 0.1               | −0.372              |
| MgSO₄    | 0.2               | −0.744              |
| K₂SO₄    | 0.1               | −0.558              |

The correct statement based on the data is ....

a. The freezing point of an electrolyte solution is higher than that of a nonelectrolyte solution

b. at the same concentration, the freezing point of an electrolyte solution is lower than that of a nonelectrolyte solution

c. The greater the concentration of a substance, the higher the freezing point of the solution

d. The greater the concentration of a substance, the higher the freezing point of the solution

e. Electrolyte solutions of the same concentration have the same freezing point

(Sutresna et al., 2016: 26)

5. **Creative Thinking**

Creative thinking is putting things together in new ways, observing things that others might have missed, building something new, using unusual or unconventional images that still work to make interesting points, and the like. Questions on the aspect of creative thinking resulted in a percentage of 1.53%.

Those questions or instructions ask students to make an experimental design using something new (derived from nearby tools and materials), based on the results of seeking information they get. The tasks or questions given must make students create according to their rights to stimulate students’ creativity.

In dealing with problems or events training creative thinking skills, students use imagination, intelligence, insight, and ideas once facing such situations. In addition, students are asked to suggest original and new designs, generate different hypotheses, and solve problems by finding something new (Birgili, 2015).

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Figure 9
Questions on Aspects of Creative Thinking

Voltaic Cells from Surrounding Materials

Often, we hear on the news, the discovery of electricity that comes from fruit. For example, *kedondong* and oranges.

1. Make groups of 3-4 people
2. Discuss with your group why the fruit can be used to generate electricity. Then, look for other fruit that you think can be used.
3. Make an experimental design to make a series of voltaic cells from these materials.
4. Submit it to your teacher, then when approved, make the Voltaic cell.
5. Present the voltaic cell that you have made in front of the class

(Purba, 2016: 97)

Conclusion

Based on the study results, it can be seen that the three chemistry textbooks used by grade XII of State Senior High Schools in South Tangerang City are still dominated by questions of low-level thinking skills. The percentage of high-level thinking skills questions in grade XII chemistry textbooks is only 25.95%, and several HOTS aspects do not exist in the textbooks, such as evaluating and making decisions.

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