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ANALYSIS OF CHEMISTRY SUBJECT SCHOOL EXAM QUESTIONS BASED ON BLOOM'S TAXONOMY REVISION AT HIGH SCHOOL 2 KARANGANYAR IN 2019, 2020, AND 2021

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ABSTRACT

Research was conducted to find out: (1) percentage of dimensions of cognitive processes, (2) Knowledge dimension percentage, and (3) the combined percentage of the two according to Bloom's Taxonomy Revision on School Exam (US) Chemistry questions at SMAN 2 Karanganyar in 2019, 2020, and 2021. This research is a qualitative descriptive research. The method used is document analysis. Data is sourced from documents on US chemistry at SMAN 2 Karanganyar in 2019, 2020, and 2021. Sampling using purposive sampling. Validity tests are carried out with credibility and dependability tests. The results of research on US Chemistry problems in 2019, 2020, and 2021 showed: (1) the percentage of cognitive process dimensions respectively, namely C1 (12.5%; 12.5%; 7.5%), C2 (22.5%; 37.5%; 20%), C3 (40%; 37.5%; 17.5%), C4 (25%; 12.5%; 17.5%), C5 (0%), and C6 (0%); (2) the percentage of knowledge dimensions respectively, namely factual knowledge (10%; 12.5%; 7.5%), conceptual knowledge (55%; 57.5%; 55%), procedural knowledge (35%; 30%; 37.5%), and metacognitive knowledge (0%); (3) the combined percentage of cognitive process dimensions and knowledge dimensions, namely C1-factual (7.5%; 7.5%; 5%), C1-conceptual (5%; 5%; 2.5%), C2-factual (2.5%; 5%; 2.5%), C2-conceptual (20%; 32.5%; 15%), C3-conceptual (12.5%; 12.5%; 20%), C3-procedural (27.5%; 25%; 37.5%), C4-conceptual (20%; 7.5%; 17.5%), C4-procedural (5%; 5%; 0%). The quality of the US question could be better, because the composition is not in accordance with the standards set by BSNP.

***Keywords**: Cognitive Process Dimension, Knowledge Dimension, Revised Bloom's Taxonomy, School Exam (US)*

INTRODUCTION

Education is a systematic effort made so that each human being can reach a particular stage in the stage of life, namely obtaining physical and mental happiness. [1]. In human life, education plays a vital role; this makes education can be placed at the highest level of human needs. Various efforts are made to improve the welfare of human life by increasing education and knowledge. [2]. Education also plays a vital role in the development of a country, where education can determine whether a country is classified into developed or developing countries [3].

Success in the learning process not only depends on the teacher's ability to develop and understand teaching materials and teacher skills in managing the classroom but also on the teacher's ability to assess the performance of student learning outcomes [4]. The assessment system is a method used to improve the quality of education. Evaluation is an activity carried out to see the condition of an object using instruments or tools and compare the results as a benchmark to draw a conclusion[5]. The success of this evaluation activity is determined by the accuracy of the implementation of the exam, in which an instrument for assessing learning outcomes is needed[6]. Test and non-test are two types of evaluation tools[5]. One of the most

commonly used methods is a test. The test is one of the assessment tools or instruments in the form of tasks that must be completed by students to obtain a student learning achievement score[7]. One of the tests tested at the High School education level is the School Examination (US) which aims to assess students' understanding of the material in each field of study at the end of the study period.

If the technical and substantial requirements are met, the assessment instrument presented can be categorized as good. Technical requirements are the level of validity, reliability, and transparency, while substantial requirements are meaningful assessments for students to achieve a goal [8]. However, there are still many assessment instruments that are substantially located only at the lower order thinking skill, which students less effectively use to overcome problems [8].

It is essential to conduct a study to analyze the quality of each question item tested. Question point analysis is a study carried out so that a test instrument has a question set with good quality. [6]. Some researchers have conducted item analysis using the Revised Bloom Taxonomy as a benchmark to assess whether a question falls into the LOTS or HOTS category. [8]. Bloom's Revised Taxonomy includes six cognitive levels that can be used to determine the depth of the questions to be tested and can map the level of thinking skills of students. Bloom's Revised Taxonomy is used because it can see learning objectives more clearly and accurately.[9]. Based on BSNP, the cognitive process dimension in the Revised Bloom Taxonomy is used as the primary basis for preparing indicators of exam questions to be tested on students.

According to Syahida dan Irwandi (2015) research The 2013 Chemistry National Exam (UN) showed that the percentage of cognitive levels was 12.5% in C1, 37.5% in C2, 35% in C3, 15% in C4, and 0% in C5 and C6. From these data, it can be concluded that the questions tested do not meet the requirements to be categorized as good questions. According to BSNP, the percentage of good questions in terms of cognitive level is 25-30% for cognitive level of knowledge and understanding (C1 and C2), 50-60% for cognitive level of application (C3), and 10-15% for cognitive level of reasoning C4, C5, and C6). The unevenness in the percentage distribution of these questions can illustrate that the questions presented need to be more able to encourage students to use thinking capabilities at the highest level (Higher Order Thinking Skills), such as creative, critical thinking, and analytical. [11].

Based on observations, it is known that research has yet ever to be conducted on the analysis of the Chemistry School Exam (US) based on the Revised Bloom Taxonomy at High School 2 Karanganyar in 2019, 2020, and 2021. As a result, we cannot assess the quality of the School Exam (US) questions tested on students. So researchers need to conduct research on the quality of the school exam questions to determine whether the questions tested are suitable to be a good assessment instrument and have paid attention to the cognitive aspects to be achieved by competency. The questions used in this study are questions in 2019, 2020, and 2021, because they are considered to be able to provide an updated picture of the distribution of each level in the Revised Bloom Taxonomy on School Examination questions tested on students during the COVID-19 pandemic.

RESEARCH METHOD

The study occurred from February 2021 to October 2022 at High School 2 Karanganyar. Using a type of qualitative descriptive research emphasizes more on notes that provide a detailed, complete, and in-depth picture to image the actual situation to support the presentation of information [12]. The data source used in this study is the question documents and grids of Chemistry US High School 2 Karanganyar in 2019, 2020, and 2021. The sampling technique used in this study is purposive sampling. The data collection technique used is the analysis of document content. The data analysis technique carried out in this study is to

review the school exam questions to determine the cognitive poses dimension and knowledge dimension based on the Revised Bloom Taxonomy. This study conducted a series of data validity tests, namely credibility and dependability tests. The credibility test technique used in the study is researcher triangulation, involving two raters. The dependability test is carried out by checking the entire research process by two research supervisors.

RESULTS AND DISCUSSION

The US questions analyzed amounted to 120 items, consisting of 110 multiple-choice items and 10 description items.

A. Dimensional Analysis of Cognitive Process

The distribution of each level of cognitive process dimension in the school examination questions is shown in Table 1.

Table 1. Distribution of Cognitive Process Dimensions in Chemistry US in 2019, 2020, and 2021

Dimensions of Cognitive Processes	Number of Questions	Percentage (%)
Memorizing (C1)	13	10,83
Understan-ding (C2)	31	25,83
Applying (C3)	55	45,83
Analyzing (C4)	21	17,5
Evaluating(C5)	0	0
Creating (C6)	0	0

From Table 1, it can be concluded that the distribution of the emergence of cognitive process dimensions in the School Examination has different proportions at each level. The cognitive level of applying (C3) dominates the school exam questions, followed by the emergence of questions with the cognitive level of understanding (C2). The data is in line with the research Sunggarani (2013) which analyzed the Indonesia National Science Olympiad (OSN) Chemistry questions in 2012 and 2013, where it was found that the question instrument was dominant in the emergence of cognitive level questions applying (C3).

The cognitive level of memory (C1) is the lowest cognitive process in the dimension level of cognitive processes according to Bloom's Revised Taxonomy [14]. However, the C1 level is essential because it can be a provision for the learning process and a basis for solving problems in complex tasks [9]. An example of this cognitive remembering (C1) tiered question is question number 24 (School Exam in 2021).

Sistem penyangga dalam cairan intra sel tubuh yang berperan dalam ekskresi ion H^+ pada ginjal adalah ….

A. $H_2PO_4^-$ dan HPO_4^{2-}
B. H_2CO_3 dan HCO_3^-
C. $Al(OH)_2^+$ dan $ALOH^{2+}$
D. HCO_3^- dan CO_3^{2-}
E. $H_2PO_4^-$ dan PO_4^{3-}

This problem is categorized in the remembering level (C1) because to be able to show the pair of ions/buffer compounds in cells, students only need to dig up their memories about the buffer solution.

The cognitive level of understanding (C2) means that students can construct meaning based on knowledge already possessed and associate new knowledge with old knowledge obtained by students [9]. Question number 7 (US in 2020) is an example of the question.

Perhatikan data hasil percobaan uji larutan elektrlit berikut,

No	Larutan	Pengamatan	
		elektroda	Lampu
1	P	Tidak ada gelembung	Padam
2	Q	Gelembung sedikit	Padam
3	R	Gelembung sedikit	Redup
4	S	Gelembung banyak	Redup
5	T	Gelembung banyak	Menyala

Larutan elektrolit kuat dan non elektrolit berturut – turut ditunjukan nomor ....

A. 1 dan 3 C. 4 dan 5 E.5 dan 3
B. 2 dan 5 D. 5 dan 1

This question is categorized in the level of understanding (C2)

because students are required to understand the concepts of electrolyte and non-electrolyte solutions and classify them based on differences in electrical conductivity produced.

The cognitive level of applying (C3) means that students can use accurate measures to solve a problem presented[9]. An example of a cognitive level question applying (C3) is question number 9 (School Exam in 2019).

Dari uji 2 jenis air limbah dengan beberapa indikator didapat data sebagai berikut:

Indikator	Trayek pH	Perubahan Warna	Air Limbah A	Air Limbah B
Phenolftalein	8,3 – 10	Tidak Berwarna - Merah	Tidak berwarna	Tidak berwarna
Metil Merah	4,2 – 6,2	Merah – Kuning	Kuning	Merah
BTB	6,0 – 7,6	Kuning – Biru	Biru	Kuning

Harga pH dari air limbah A dan B berturut-turut adalah….

A. $7,6 \leq pH \leq 8,3$ dan $pH \leq 4,2$
B. $6,2 \leq pH \leq 8,3$ dan $pH \leq 4,2$
C. $pH \leq 4,2$ dan $7,6 \leq pH \leq 8,3$
D. $7,6 \leq pH \leq 10$ dan $4,2 \leq pH \leq 6,0$
E. $8,3 \leq pH \leq 10$ dan $pH \leq 8,3$

In the question above, students are required to calculate the pH value of a solution based on data on changes in solution color after being given an indicator. Students must be able to apply procedures in accordance with the concept of pH, namely by drawing pH route diagrams to determine the pH price of wastewater A and B. Therefore, the problem is categorized as a dimension of cognitive process applying (C3).

The cognitive level of analyzing (C4) means that students can describe a material and determine the relationship of these elements [9]. Question number 14 (US in 2020) is an example of the question.

Ke dalam 5 wadah yang berbeda, masing-masing berisi 100 mL larutan $Ca(NO_3)_2$, $Ba(NO_3)_2$, $Fe(NO_3)_2$, $Mg(NO_3)_2$, $Pb(NO_3)_2$, 0,01M, kedalam tiap wadah tersebut ditam bahkan 100 mL larutan NaOH 0,01 M, maka pasangan senyawa yang diprediksi tidak membentuk endapan adalah ....

(Ksp $Ba(OH)_2 = 4 \times 10^{-3}$; $Mg(OH)_2 = 3 \times 10^{-12}$; $Pb(OH)_2 = 3 \times 10^{-16}$; $Ca(OH)_2 = 5 \times 10^{-6}$; $Fe(OH)_2 = 5 \times 10^{-16}$)

A. $Ba(OH)_2$ dan $Ca(OH)_2$
B. $Ba(OH)_2$ dan $Mg(OH)_2$
C. $Ca(OH)_2$ dan $Fe(OH)_2$
D. $Mg(OH)_2$ dan $Pb(OH)_2$
E. $Fe(OH)_2$ dan $Pb(OH)_2$

In this problem, students are required to be able to understand the concept of solubility and solubility products, to determine the mixture of salts that produce precipitate by analyzing the results of calculating the Qsp value and relating it to the relationship between the Ksp value and the Qsp value. Therefore, the problem is categorized in analyzing cognitive processes (C4).

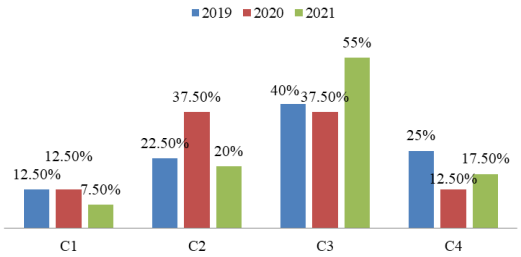
In the school examination questions analyzed, there was no appearance of cognitive level questions evaluating (C5) and creating (C6). The reason why the cognitive level of evaluating (C5) and creating (C6) is rarely found in the questions tested on students is because of the form of the questions presented in the exam [15]. Cognitive level evaluating (C5) and creating (C6) are challenging to measure using multiple-choice questions, because the two cognitive levels emphasize more on productive skills [15]. Furthermore, based on interviews with chemistry teachers, the absence of cognitively evaluating (C5) and creating (C6) questions was due to concerns that students could not do questions at the cognitive level. Due to the limitations of the learning process during the pandemic which was forced to be carried out online, it made it difficult for teachers to implement HOTS-based learning. So, the evaluation questions tested on students also undergo adjustments in

quality so that students can get satisfactory final results.

In general, these School Examination questions need to be revised to be considered good. The percentage of good questions in terms of cognitive level, according to BSNP, is 25-30% for the cognitive level of knowledge and understanding, 50-60% for the cognitive level of application, and 10-15% for the cognitive level of reasoning. The study results found that the questions were dominated by the cognitive level of applying (C3) with a percentage that exceeded the criteria for good questions. In the HOTS category, the School Exam questions only present questions with a cognitive level of analyzing (C4).

Teachers are expected to equip and develop the mindset of students to be more focused on application, analysis, and reasoning by creating a learning system based on HOTS, prioritizing C4, C5, and C6 levels. And continue to develop HOTS-based questions while considering the balance of the composition of LOTS-based questions. HOTS-based questions can stimulate students to think more deeply about the subject matter given. In addition, to mature the readiness of students to face competition at the global level, students need to improve their ability to think critically and creatively and overcome existing problems. Viewed from year to year, US questions tested on students have decreased in cognitive quality, especially in 2020, marked by a decrease in the percentage of HOTS questions. In 2019, the C4 question had a percentage of 25%, while in 2020 and 2021, it was only 12.5% and 17.5%. This decrease is due to adjustments to the state of the teaching and learning process that cannot be carried out optimally due to the COVID-19 pandemic, which has resulted in learning having to be carried out online. So, the questions tested must also be adjusted so that students still get maximum scores. For levels C1, C2, and C3, which are LOTS, the percentage fluctuates. This can be seen in Figure 1.

Figure 1. Cognitive Process Dimensions Dissemination Graphics



B. Knowledge Dimension Analysis

The distribution of each type of knowledge dimension in the US chemistry problem of High School 2 Karanganyar in 2019, 2020, and 2021 is shown in Table 2.

Table 2. Distribution of Knowledge Dimensions of US Chemistry Questions in 2019, 2020, and 2021

Knowledge Dimension	Total Item	Percentage (%)
Factual	12	10
Conseptual	65	54,17
Procedural	43	35,83
Metacognitive	0	0

Factual knowledge includes fundamental elements that students must understand when they want to master a scientific field and solve problems encountered in the scientific field.[9]. An example of the question is number 2 (School Exam in 2019).

Perhatikan simbol gambar dan arti dari bahan kimia berikut :

1.berac un	2.pengo ksidasi	3.radioakt if	4.mudah terbakar	5.koros if

Dari symbol gambar dan arti bahan kimia di atas yang sesuai adalah … .

A. 1 dan 2
B. 2 dan 3
C. 2 dan 4
D. 3 dan 4
E. 4 dan 5

This problem is categorized as factual knowledge because students need to know the terminology, including symbols and images, to solve it.

Conceptual knowledge can form schemes, models, and theories from a scientific field, either implicitly or explicitly.[9]. An example of a conceptual knowledge problem is question number 8 (US in 2021).

Percobaan mereaksikan belerang (S) dengan gas Oksigen (O_2) menghasilkan belerang trioksida (SO_3), diperoleh data sebagai berikut,

Percobaan	Massa S (g)	Massa O (g)	Massa SO_3 (g)
1	15	22,5	35
2	12	18	28
3	10	15	25
4	4	4,5	7,5

perbandingan massa unsur S dan O dalam senyawa SO_3 adalah ….

A. 3 : 2
B. 3 : 4
C. 3 : 5
D. 2 : 3
E. 2 : 5

This question is categorized under conceptual knowledge because to solve it, students must know the theories and concepts of the fundamental laws of chemistry.

Procedural knowledge is the knowledge of how to do something to solve a problem[9]. Question 11 (US in 2020) is an example of procedural knowledge.

Disajikan data hasil percobaan titrasi larutan NaOH dengan 0,1M dengan larutan HCl yang dilakukan oleh siswa SMA N 1 Semangat Maju sebagai berikut,

No	Volume NaOH (mL)	Volume HCl (mL)
1	10	20
2	9	20
3	11	20

besarnya konsentrasi larutan HCl pada titrasi tersebut adalah ….

A. 0,100 M
B. 0,050 M
C. 0.025 M
D. 0,020 M
E. 0,010 M

In this problem, students must be able to determine the molarity of a compound based on the titration results. So in doing this problem, students must apply knowledge of criteria to determine the application of an appropriate procedure to calculate the molarity of the compound. So, this matter is classified as procedural knowledge.

US Chemistry questions in 2019, 2020, and 2021 are dominated by conceptual knowledge, with a percentage of 54.17%. These results are in line with the research Enero, dkk (2017) regarding the analysis of chemistry exam questions in several high schools in the West African region, where it is known that conceptual knowledge contributes the highest number of occurrences with a percentage of 49.4%. Based on these results, it can be observed that more emphasis is placed on students' understanding of chemical concepts in the questions tested.

Meanwhile, metacognitive knowledge did not appear in the question instruments analyzed. The reason is it is difficult to measure metacognitive knowledge using simple written test instruments. Metacognitive knowledge is usually found to appear in discussions and activities carried out during the learning process in the classroom, where during the discussion activities, students will realize and compare the

strategies they have with the strategies of other students[9].

C. Combined Analysis of The Cognitive Process Dimension and The Knowledge Dimension

The relationship between the cognitive processes dimension and the knowledge dimension in Bloom's Revised Taxonomy is called the taxonomic table, presented in Table 3.

Tabel 3. Taxonomy Table

Knowledge Dimension	Dimensions of Cognitive Process					
	C1	C2	C3	C4	C5	C6
Factual Conceptual Procedural Metacog-nitive	**LOTS**			**HOTS**		

The distribution of the emergence of each combination of dimensions of cognitive processes and knowledge in the US Chemistry problem of High School 2 Essays in 2019, 2020, and 2021 are shown in Table 4.

Table 4. Combined Distribution of Cognitive Process Dimensions and Knowledge Dimensions of US Chemistry Questions High School 2 Karanganyar in 2019, 2020, 2021

Cognitive Process Dimension and Knowledge Dimension	Total Item	Percen-tage (%)
C1-Factual	8	6,67
C1-Conseptual	5	4,17
C2-Factual	4	3,33
C2-Conseptual	27	22,5
C3-Conseptual	18	15
C3-Procedural	36	30
C4-Conseptual	18	15
C4-Procedural	4	3,33

The chemistry school exam questions at High School 2 Karanganyar in 2019, 2020, and 2021, which were analyzed based on the dimensions of cognitive processes and knowledge of the Revised Bloom Taxonomy, were dominated by the emergence of a combined level of applying (C3)-procedural, with a percentage of 30%. This is in accordance with research on the analysis of IJSO Science (Chemistry) questions by Yunita (2017), where the C3-procedural level contributed the highest percentage of occurrences, which was 23.52%.

The dominance of the emergence of the C3-procedural level shows that these problems test the ability of students to apply the right procedures and formulas to solve them. The problem contains mole concept material, acid-base pH, thermochemistry, redox reactions, reaction rate, voltaic cells, and so on. An example of the question is number 10 (School Exam in 2019).

Untuk menentukan molaritas larutan CH_3COOH dilakukan dengan titrasi menggunakan larutan standar $Ca(OH)_2$ 0,05 M. Data titrasi diperoleh sebagai berikut:

Percobaan	Volume CH_3COOH (mL)	Volume $Ca(OH)_2$ (mL)
1	20	21
2	20	20
3	20	19

Molaritas larutan CH_3COOH sebesar….
A. 0,8 M
B. 0,6 M
C. 0,4 M
D. 0,2 M
E. 0,1 M

This problem requires students to apply the concept of titration to calculate the molarity of a titrate, so that the problem is classified in the applying level (C3). And in doing problems, students must apply an appropriate procedure and mathematical calculations, so the questions contain procedural knowledge. Therefore, this question is classified at the C3-procedural level.

Because of the relationship between the dimensions of cognitive processes and knowledge based on the Revised Bloom Taxonomy, the emergence of questions with the cognitive level of evaluating (C5) and creating cognitive levels (C6) can spur the emergence of metacognitive knowledge in students. According to research on the development of HOTS questions on physics exam question instruments carried out by Kusuma, et al (2017), it is found that HOTS questions that have been developed containing metacognitive knowledge dimensions can improve the quality of questions and stimulate students' capabilities to think critically. So to improve the quality of School Examination questions, questions containing C5 and C6 levels and metacognitive knowledge dimensions need to be presented in the form of essays.

CONCLUSION

Based on the results of the research and discussion that have been described, on the US Chemistry question of High School 2 Karanganyar in 2019, 2020, and 2021, it was obtained that:

1. The percentage of occurrence of each level in the cognitive process dimension respectively is C1 (12.5%, 12.5%, 7.5%), C2 (22.5%, 37.5%, 20%), C3 (40%, 37.5%, 17.5%), C4 (25%, 12.5%, 17.5%), C5 (0%), and C6 (0%). The questions presented have yet to meet the standard criteria for good questions.
2. The percentage of each type of knowledge dimension is factual knowledge (10%, 12.5%, 7.5%), conceptual knowledge (55%, 57.5%, 55%), procedural knowledge (35%, 30%, 37.5%), and metacognitive knowledge (0%).
3. The combined percentages of the cognitive process dimension and the knowledge dimension were C1-factual (7.5%, 7.5%, 5%), C1-conceptual (5%, 5%, 2.5%), C2-factual (2.5%, 5%, 2.5%), C2-conceptual (20%, 32.5%, 15%), C3-conceptual (12.5%, 12.5%, 20%), C3-procedural (27.5%, 25%, 37.5%), C4-conceptual (20%, 7.5%, 17.5%), C4-procedural (5%, 5%, 0%).

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