

National chemistry exam: Get students “to HOTS” or “just hot”?

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Abstract. Practicing 21st-century skills for Indonesian students is one of the national chemistry exam goals. Critical thinking skills and problem-solving skills, as 21st-century skills, trained through higher-order thinking questions in the national chemistry exam. The study is to explore students' perceptions and experiences of HOT questions in the national chemistry exam. Fifty-one secondary students, who had conducted the 2019 national chemistry exam, participated in this study. Students filled out a questionnaire consisting of 11 closed questions with reason. Some students were also interviewed to find out their perceptions more. This study applied descriptive qualitative data analysis. Data analysis showed that students find difficulty in doing HOT questions. It made them feel ‘hot’ and not get higher-order thinking skills (HOTS) yet. There are several reasons; those are lack of concepts understanding, limited exam time, lack of working on HOTS-oriented questions, and lack of critical thinking skills. Teachers must train students to become accustomed to HOTS-oriented questions so students can be highly competitive in facing the 21st-century era.

1. Introduction

Chemistry contains many abstract concepts interrelated. The concepts represented in three levels; macroscopic, microscopic, and symbolic. Students, who find difficulties at one of the levels, may predispose the others. Chemistry concept difficulties are along with other concept learning difficulties. It means chemistry entail high-level skills [1]. Critical thinking skills and problem-solving skills are examples. Both skills belong to expert thinking or higher-order thinking skills to encounter a creative work era and a lifetime of learning [2,3]. Ennis (1987) defined higher-order thinking skills (HOTS) as three top levels of Bloom Taxonomy, analysis, synthesis, and evaluation [4]. Students need those skills to accomplish daily problems. Higher-order thinking skills will emerge when students confront unfamiliar problems or questions.

Moreover, the students can take new information and relate it to the stored information to find a possible answer to the problems [3,5]. Chemistry has a relation to those problems in daily life. Therefore, students who learn chemistry must have both skills to implement their knowledge. Furthermore, higher-order thinking skills not only allow students to think more complex in which the students can control it but also make students better equipped to deal with the real-world situations [6]. Unfortunately, both skills become a big problem for students who learn chemistry [7].

The problems will not arise if the students master chemistry concepts thoroughly. Understanding concepts in chemistry is essential. It makes students build meaningful knowledge, open new insights, prepare broader and deeper understanding, and enrich their life experiences [8]. Unfortunately, students who dominate the chemistry topic is relatively low. Students have difficulty in connecting previous concepts with everyday life. In Indonesia, students find difficulty in accomplishing problems analyse. TIMSS and PISA assessment results in learning science and mathematics categorized Indonesian students in a low ranked [9,10]. It means Indonesian students are not accustomed to applying the concepts of theoretical learning to their daily life in solving problems. This condition is worrying because Indonesian students will find difficulties in competing with students from other countries in the modern society era. That is why higher-order thinking skills is so essential today.

The Indonesian government is trying to train students to become more familiar with HOTS through the national exams. The national exams contain some questions-oriented to HOTS. Students trained to compare, analyse, conclude, solve problems, and apply their knowledge to their lives through the questions related to daily life problems. Chemistry is one of the subjects in the national exam for science students. The students can choose chemistry among other science subjects, such as biology and physics [11]. Over the past two years, students who have chosen chemistry as a national examination subject reduced in number. Students keep the chemistry off because of the HOT questions. Students assume HOT questions difficult. The study is vital to know whether the HOT questions in the national chemistry exams have made students think at a high level or make students confused and 'hot'. The study explores students' experiences and perceptions after doing HOT questions in the national chemistry exam. By knowing that, teachers can know students' difficulties in doing the test. So, they make their students accomplish HOT questions in chemistry subject more.

The rest of this paper is organized as follows: Section 2 describes the proposed research method; section 3 presents the obtained results and following by discussion, and section 4 presents the conclusion.

2. Research Method

This study conducted with a descriptive qualitative research design. This design involved data collecting and analyzing in a qualitative approach to obtain a deeper understanding of students' perception and experience on questions-oriented to higher-order thinking skills in the national chemistry exam. There were no treatments for the students during the study. It was a natural situation. It was conducted to provide an overview of the conditions and the facts that occur. Fifty-one secondary school graduates from four districts in Madura island participated in this study by completing an online questionnaire. The districts are Bangkalan, Sampang, Sumenep, and Pamekasan. All of the students are from science majors who selected chemistry as an elective subject in the science class.

Purposive sampling was applied to obtain 35 females and 16 males participants. Purposive sampling technique was applied to get participants who can provide information well and relate to the problems under the study. The students were asked to fill 11 closed questions with reasons out. Students were able to choose the conditions according to the students' circumstances or add new conditions according to the students' opinions and experiences. The appendix shows a list of questions. The questionnaire was prepared based on journal analysis and the national examination documents review. Two expert academicians presented their ideas about the questionnaire.

Eight participants were interviewed after completing the questionnaire. The participants were contacted by phone to confirm the interview process. The interview was conducted to confirm and complete the unclear and incomplete data. The interview was voluntary, and it was recorded. Both the interview and questionnaire were doing with Indonesian, while the findings of the study were stated in English. The interview result was transcribed and read to find trends in students' opinions and experiences about the national chemistry exam difficulties, especially in doing HOT questions. The obtained data was analyzed analytically descriptive.

3. Results and Discussion

3.1 Students' reason in selecting chemistry

Students were asked about their reasons for selecting chemistry in the national exam. Students were able to choose the conditions that have been written in the questionnaire or write down their own opinions. Besides, the students were asked to write their reasons according to their statement in the questionnaire. Students showed different answers in the questionnaire, and it was found three top trends. Most students selected chemistry because the students were fond of it. The students like both the subject and the teacher. The teacher taught students using various and unique methods. It made students interest in studying.

The other reasons students like chemistry because chemistry contains not only theories but also quantifications. Unlike biology, which only contains theory, students who did not like memorizing avoided biology and selected chemistry as their national exam subject in the science class. Students did not choose physics because the quantifications are too arduous. In chemistry, students could use both memorizing and computing.

Other reasons were the students think chemistry is quite easy to learn, but some of the students need more effort to study chemistry. Chemistry contains three main concepts; abstract, microscopic, and conceptual concepts [12]. Moreover, there are three representation levels in chemistry interconnected; macroscopic, sub-microscopic, and symbolic [1]. Each level of those representation has different characteristics and difficulties. At the macroscopic level, students can observe everything. Everything can predict is learned at the sub-microscopic level. The symbolic level involves representation to explain everything by using an analogy. Students will understand concepts in chemistry well if the students can process higher information using those three levels. Conversely, the students will find confusing in study chemistry if the students are both unable to relate those various levels and relate their previous information with the new one [1]. Furthermore, some of the students stated that chemistry was essential in the industrial era, so the students selected chemistry and tried to master the subject.

The following are selected various reasons written by the participants on the online questionnaire when they asked why the students choose chemistry in the 2019 national exam.

"I choose chemistry because it is my favorite subject, and I like to learn it."

"Because I like chemistry." (RR, HR, and FR)

"Because I can understand chemistry more than physics and biology." (RD, AM)

"Chemistry is a challenging subject." (AN, WA)

"I want to learn more and work in the chemical industry." (FR)

"I like the teacher, especially when teaching. She used a unique method." (DN, MF, and KN)

"It contains theory and quantification." (DY, FM)

"Chemistry is easier than physics." (AS, ER)

"Chemistry is a key of life." (NP)

"Because I like memorizing and computing." (HM, S)

3.2 The level difficulties of the questions in the national chemistry exam

As the students were asked about the students' perception of the difficulties of the question in the national chemistry exam, the students answered differently. Figure 1 showed the students' answers. The students assumed that the questions were quite tricky because there were some analysis questions. The students had to analyze and think logically to accomplish the problems. Some of the students inferred because the national chemistry exam contains base materials developed, and it was quite tricky.

The obtained data showed that Indonesian students have low critical thinking skills [10]. Critical thinking skills involve the ability to analyze, interpret, evaluate, summarize, and synthesize a lot of information [2]. This obtained data was in accordance with the PISA and TIMSS assessment results in 2015 [9,10].

In addition, students who stated that the national chemistry exam was complicated and very difficult due to many questions-oriented HOTS. Students find difficulty in solving those problems. The students

did not understand the chemistry concepts well, so the student could not accomplish the questions well. The students **said** that they prefer to memorize the concepts rather than understand and relate one concept to each other. It made students find difficulty in undertaking concept questions. Chemistry concepts contain three levels of representative. If students find difficulty in one of the levels, the students could not understand the chemistry concepts well [1].

The students have to learn those chemistry concepts comprehensively, not just memorized. So that students can solve many problems related to the chemistry concept well. If the students memorize more and more, it can cause misconceptions [13]. Otherwise, students who stated that the national chemistry exam was not difficult due to the students had trained to overcome similar questions with the national chemistry exam questions when they were at school. Furthermore, most of the questions were theory. The students stated that they had prepared for the national chemistry exam well both at school and at home. So, the students were able to overcome it well.

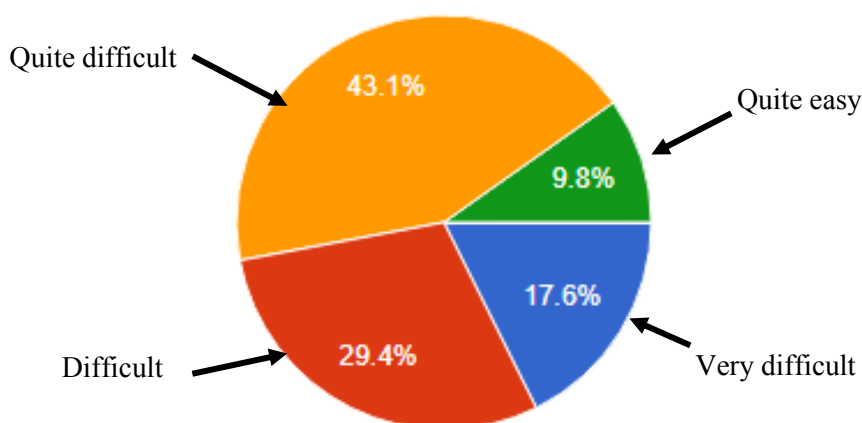


Figure 1. Students' perception of difficulty levels in the national chemistry exam

Some of the participants' reaction is stated below when they were asked about their opinion about the national chemistry exam.

"It was so difficult because it contained HOT questions." (AS, ER)

"There were many HOT questions, so it was complicated." (YM, IS, AZ)

"It was quite difficult because there are many analysis questions." (SW)

"I think it was quite easy because I have prepared it well." (AM)

"It was difficult because I could not understand the questions." (RR)

"It was difficult because the questions made me confused." (KN)

Most of the students find difficulties in the national chemistry exam in HOT questions. HOT questions required the students to think critically, and it made the students confused. Some of the students declared that abstract concept and interpretation data questions were more difficult. When the students were asked for the reason, students give different answers. They said that HOT questions required more analysis, not just memorizing theory. Students assumed they had not mastered the concepts well, and they could not both implement the concept and interrelate the concepts well. Moreover, some of the students stated that they just memorized and memorized the theory, not understood it well. So, the students found difficulty in solving concept questions.

3.2 Students' opinion of the HOT question

Almost all students stated that HOT questions in the national chemistry exam were difficult. Students less had critical thinking skills and problem-solving skills. So that students accomplished HOT questions in chemistry with difficulty. They took more time to finish one HOT question. Most students needed

more than ten minutes to accomplish a HOT question. The students took much time to analyze problems and find solutions. The students were not accustomed to those questions.

At school, in learning chemistry, the students preferred to memorize the chemistry concepts rather than understand and implement the concepts. It made students could not solve HOT and analysis questions well. The students stated that tackling the concept questions will be easier if they remember the formula.

Almost all students knew about the HOT questions, but the students did such questions rarely. Most students found the HOT questions and practised doing the questions at school and course. Unfortunately, most of the teachers give HOT exercises for students only toward the national chemistry exam. It made students not familiar and found many difficulties to solve those kinds of questions. Some teachers also gave HOT questions during classroom learning, but it was seldom.

The followings are part of the interviews conducted with one of the participants when they asked about their opinion of the HOT question.

Researcher: "Did your teachers give HOT or analysis questions as exercise?"

Students: "No, it did not. It was seldom."

Researcher: "When did it give?"

Student: "When additional lessons toward the national exam."

Researcher: "What kind of HOT questions your teacher gave?"

Student: "It was questions of the previous year's national chemistry exam."

4. Conclusion

The study obtained that Indonesian students find difficulty in doing HOT questions in the national chemistry exam. The exam makes the students feel 'hot' and not get higher-order thinking skills (HOTS) yet. Most students were confused with HOT questions and how to solve them. Several reasons cause this problem. Students are not only a lack of conceptual understanding but also a lack of working on HOTS-oriented questions.

Moreover, students are lack critical thinking skills. Students were not familiar with HOT questions. The findings implied that the teachers must train the students to become accustomed to HOTS-oriented questions. The teachers must give HOT questions for students not only to deal with the national chemistry exam but also to get the students familiar through the daily tests. So, the students can be highly competitive in facing the 21st-century era.

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Appendix

1. I select chemistry as the elective exam in the national exam 2019 because....
 - a. I like the subjects
 - b. I like the teacher
 - c. It is easy to learn
 - d. It contains both theory and quantification
 - e. Other:The reasons:.....
2. In my opinion, the questions in the national chemistry exam 2019 are difficult.
 - a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Strongly disagreeThe reasons:.....
3. I find difficulty in part of the questions: (Students can choose more than one answer)
 - a. Quantification
 - b. Theory
 - c. Higher-order thinking (Analysis)
 - d. Application
 - e. Experiment data interpretation
 - f. Abstract material
 - g. Other:The reasons:.....
4. In my opinion, the test time in the national chemistry exam 2019 is sufficient.
 - a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Strongly disagreeThe reasons:
5. I already know about the question oriented higher-order thinking skills (HOTS).
 - a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Strongly disagreeThe reasons:
6. I often practice with the HOT questions.

- a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Strongly disagree
- The reasons:.....
7. I got the exercises of HOT questions at: (Students can choose more than one answer)
- a. School
 - b. Course
 - c. Private courses
 - d. Home
 - e. Other:
- The reasons:.....
8. My chemistry teacher often gives me HOT questions exercises.
- a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Strongly disagree
- The reasons:
9. My chemistry teacher gives HOT questions exercises when:
- a. Learning activities
 - b. Daily tests
 - c. Toward national exam
 - d. Additional lesson
 - e. Other:
- The reasons:.....
10. In my opinion, the national chemistry exam is easy.
- a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Quite disagree
- The reasons:.....
11. I need more than 10 minutes to undertake a HOT question in the national chemistry exam.
- a. Strongly agree
 - b. Agree
 - c. Quite agree
 - d. Disagree
 - e. Quite disagree
- The reasons: