The development of assessment higher order thinking skills (HOTS) through online based application

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Abstract. This research is aimed to produce the instruments of the assessment on the content testing of the chemistry Higher Order Thinking Skills (HOTS) through online-based application which is intended for the pre-service chemistry teachers. To find out the data, the authors utilize (Research and Development) methodology. Furthermore, the testing of the assessment instruments on the content testing of the Chemistry Higher Order Thinking Skills through an online-based application is conducted at the department of chemistry education, Syarif Hidayatullah State Islamic University of Jakarta. What is more, the authors investigate in-depth the instrument of the assessment on the content testing of the chemistry Higher Order Thinking Skills (HOTS) through online-based application in order to obtain the data of the research. Then, all of the data gathered will be validated by two chemistry experts, and examined to seventy pre-service Chemistry teachers at the Chemistry Education Department Syarif Hidayatullah State Islamic University of Jakarta. Importantly, some instruments in collecting the data are provided, including the observation sheets, the structured-interview sheets, experts’ validation sheets, as well as the students’ questionnaires. Moreover, the data gained from the students’ responses will be tabulated to look for its percentages. After that, all of the data will be analyzed descriptively. Therefore, based on the result, it seems to indicate that the pre-service teachers’ show a good response on the assessment of the content testing of the chemistry Higher Order Thinking Skills (HOTS) through online-based application with the average percentage reaches into 85.91 %.

1. Introduction
Chemistry is one of the important subjects to learn in the senior high school level, particularly for those students who concern in the science subjects. In fact, the science students still face some difficulties in solving the chemistry problems. For instance, teacher-centered strategy, lack of facilities and infrastructures, limited teaching methodology, and other factors that can influence the students in learning Chemistry. So, these problems become the challenges for the chemistry educators that need to be accomplished.

Moreover, the chemistry teachers should possess qualified knowledge about how to explain the learning materials properly and respond the other factors in the teaching process, such as the teachers’ understanding of the curriculum used, the materials development from the syllabus, and understanding the students’ background. Also, the teachers should conceive the pedagogy knowledge that supports them in transferring the knowledge to the students.

Related to the contents used in the teaching and learning process, the teachers are required to master the learning materials and the pedagogy knowledge in its early development. Whereas,
nowadays, the teachers are obliged to have a good competence in terms of knowledge, learning materials, and teaching strategy using technology.[1]

Furthermore, some factors can influence the teachers and the schools to prepare and develop the students’ ability in fulfilling the challenges in 21st Century, including the teachers’ pedagogy ability, and the use of information technology and communication [2]. In line to the development of technology and global information, the development of science is also increased drastically which the global information can be accessed from various countries including Indonesia. Through its development, the pre-service teachers are suggested to use the technology actively in teaching and learning process [1][3]. In addition, the students of Chemistry education as the pre-service teachers must be able to elaborate the ability of design and pedagogy, understand the materials given and the appropriate technology to the students in the digital era. Likewise, to achieve the learning objectives, the students must be provided by facilitating the technology in learning process.

The development of teachers’ profession which emphasizes on the Higher Order Thinking Skills (HOTS) will neglect the basic knowledge theory by promoting the problems in learning [4]. argued that problem solving is one of important things for the students to develop their higher order thinking skills optimally. In addition, the enhancement of higher order thinking skill has become one of the priorities in learning science subjects in the schools. The Ministry of Education and Culture regulation Number 21 Year 2016 indicated that the science subjects (Chemistry, Physics, and Biology) are given to all of the students in evolving the students’ creative thinking, their critical and analytical thinking, and their teamwork skill [5].

Similarly, the Ministry of Education and Culture regulation Number 23 Year 2016 explained about the 2013 Curriculum focusing on the metacognitive ability and required the students to be able in predicting, designing, and estimating the learning materials. [5] This regulation has been implemented in computer-based national examination in 2018 consisting of many questions of the higher order thinking skills (HOTS). Notably, the HOTS questions contain of the analysis questions that examine the students’ thinking skill and specify the elements in a certain context. By contrast, the students only utilize papers and pencils in the concept understanding test. Thus, the materials tested to the teachers consist of 30 percent of the pedagogy competence and 70 percent of the professional competence. Particularly, the pedagogy competences include the teachers understanding of the pedagogy and its implementation in teaching process in the class. While, the professional aspect is specified to examine the teachers’ performance based on their academic teachers’ qualification.

In light of the importance of the critical thinking, it should be developed for the students because through the critical thinking, they may easier to understand a concept, able to implement the context in a different situation and become more sensitive towards the problems. Further on, high order thinking skill possesses some additional aspects that support the students’ skills. For instance, proposing the complex questions, showing the consistency of an argument, as well as thinking critically. According [2], these skills are needed by the pre-service teachers in order to develop the others skills in the modernization era and think in-depth about a certain issue. Therefore, the authors seem interested in developing the assessment instrument focusing on Higher Order Thinking Skills (HOTS) through online-based application to the pre-service chemistry teachers. [6]

2. Literature Review

In general, the word “think” is defined as a cognitive process of a mental activity aimed to obtain knowledge. Thinking also can be explained as the process of manipulating data, facts, and information to decide a decision [7]. Moreover, the mental activity in feeling and activity are based on the external stimulation called sensation and attention [8] The higher mental process is also known as the process of thinking in mind.

Essentially, thinking is an activity to devote ideas in mind for a particular purpose. It can become a differentiator which separated the human and creatures. So, the humans deserve to be called human beings because they are able to organize their mind by themselves. What is more, thinking is classified into a cognitive part, which is divided into several stages based on Bloom taxonomy. For instance,
knowing, understanding, implementing, analyzing, synthesizing, and evaluating. All of the stages are included in a series of the thinking process. According to the stages, the three lowest stages are called lower order thinking and the three highest stages are called higher order thinking. Therefore, it can be said that the stages included in the higher order thinking are (1) analyzing, evaluating, and creating, (2) logical reasoning, (3) critical thinking, (4) problem solving, and (5) creative thinking [9].

In general, thinking ability consists of four phases, which are recall thinking, basic thinking, critical thinking, and creative thinking which need higher order thinking skills. It is categorized in the stages of analysis, creative thinking, critical thinking, problem solving, and visualization [10]. Higher order thinking skill have some relevant aspects, in terms of proposing the complex questions, showing the consistency in argumentation, and thinking critically. These skills are needed for the development of students’ thinking as the pre-service teachers [6]. In line, Heong et al. stated that higher order thinking skills is a representation of the important aspect in teaching and learning process in the higher education. He assumed that the students who have the higher order thinking skills can be easier to study the learning materials, develop their work, and decrease their weaknesses [11].

The ability to think critically is a fundamental process in the education. It can influence the students’ ability in learning the materials given. Also, it affects the students effectiveness in doing the activities in the classroom. Therefore, thinking process is related to the teaching and learning process which may reflect the positive impacts to the development of education [11]. Anderson and Krathwohl (2001) have revised the use of Bloom's Taxonomy as a conceptual framework for research into higher-order thinking skills [12] seemed to suggest that in Bloom's Taxonomy a revision of skills that involves analysis, evaluation, and creating, which is considered a high-level thinking skill. In line, stated that the indicators in measuring the higher-order thinking skills include analyzing, evaluating, and creating [12].

3. Method
In order to find out the data, the authors utilize R&D (Research and Development) methodology. Furthermore, the testing of the assessment instruments on the content test of the Chemistry Higher Order Thinking Skills through an online-based application is conducted at the department of chemistry education, Syarif Hidayatullah State Islamic University of Jakarta. What is more, the authors investigate in-depth the instrument of the assessment on the content test of the chemistry Higher Order Thinking Skills (HOTS) through online-based application in order to obtain the data of the research. Then, all of the data gathered will be validated by two chemistry experts, and examined to seventy pre-service Chemistry teachers at the Chemistry Education Department Syarif Hidayatullah State Islamic University of Jakarta.

In developing the assessment on the content test of chemistry higher order thinking skill through online-based application, the authors provide three steps adopted from Warsita (2008), such as needs’ analysis phase, development phase, and evaluation phase. [13]
Figure 1. Research Procedures

Notably, some instruments in collecting the data are provided. For instance, the observation sheets, which are used to identify the assessment instrument on the content test. Another one is the structured-interview sheets, that are utilized to obtain the information about the assessment implementation on the content test. Also, the authors administrate the experts’ validation sheets in order to get the consideration from the experts toward the instruments that can be revised. What is more, the students’ questionnaires become one of the important instruments in this research because the questionnaire are intended to measure the students’ responses towards the developed instruments.

The data obtained from the assessment sheet are searched for the percentage and then analyzed. In the questionnaire students’ responses were analyzed using a graded rating scale. According to Sugiyono (2014) for rating scale with five alternative answers can be made with numbers from 4 to 0. Very good answers given a number 4, good given a number 3, good enough given a number 2, not good given a number 1 and very not good given a number 0. [14] Data processing questionnaire student responses using a five-scale response. Data analysis is done by simplifying the data into a form that is easier to read and interpreted so that the data obtained can be analyzed and concluded. Results data from the student response questionnaire were then tabulated and the percentage sought after was analyzed descriptively. The answers’ percentage for each item can be scored by using the following formula.

\[
\text{Percentage} = \frac{\sum \text{All of the students' score} \times 100}{\sum \text{students} \times 4}
\]

Then, the authors determine the categorization of the assessment to obtain the conclusion whether developing the assessment instruments on the content testing of the chemistry higher order thinking skills through online-based application. For example, excellent/very good (81-100), good (61-80), Bad (21-40), very bad (0-20).

4. Result and Discussion
Based on the result of the research, the authors found the data related to the development process of the assessment on the Higher Order Thinking Skills (HOTS) through online-based application in basic chemistry course.
4.1. The Data of the Product Development Process

The development process of the assessment instruments on the higher order thinking skills through online-based application could be divided into three phases, such as planning, drafting HOTS indicators, and producing the online-based application.

The first process in the planning phase was collecting the information through the needs’ analysis. It was carried out in the beginning of the research to find out the specific and specific information.[15] In this stage, the authors conducted an in-depth observation at one of the universities. Furthermore, based on the observation, the data seemed to indicate that the process of learning and assessment have not included yet the higher order thinking skills and have not done yet through online. After carrying out the needs’ analysis, the authors undertook the literature reviews about the importance of assessment and higher order thinking skills role from various resources. Also, the authors defined the skills that might be had by the students, formulated the learning objectives, and determined the learning steps. Moreover, the formulation of the learning objectives and the learning stages were carried out by analyzing the learning objectives of the study program and the learning objectives of the basic chemistry course. Below was the analysis result between the learning objectives of the study program and the learning objectives of the basic chemistry course.

| THE LEARNING OBJECTIVE OF THE STUDY PROGRAM | NO | THE LEARNING OBJECTIVES OF THE COURSE | DISCUSSION MATERIALS |
|--------------------------------------------|----|--------------------------------------|----------------------|
| PLO: P-6 Implementing the basic concept of science and mathematics in solving the chemistry problems | P.6.1 | Classify the materials based on the physical and chemical characteristics and the changes | Materials, characteristics, and measurement |
| | P.6.2 | Explain the theory and structure of atom | Atom structure |
| | P.6.3 | Explain the periodic system and its characteristics | Periodic system |
| | P.6.4 | Determine kinds of chemical bonds based on the constituent elements and connect them to the chemical characteristics and molecular physics. | Chemical bonds |
| | P.6.5 | Explain the basic law and concept of mol in the chemistry calculation | Stoichiometry |
| | P.6.6 | Analyze the characteristics of solvent based on the number of solutes | The characteristics of solutes |
| | P.6.7 | Predict the shifting of the balance based on the Le Chatelier principle | Chemical balance |
| | P.6.8 | Implement the concept of acid base in reaction and chemical counting | Acid, base, and pH concept |
| | P.6.9 | Implement the theory of thermodynamics in physics and chemical changes | Thermochemistry and thermodynamics |
| | P.6.10 | Describe the intra energy and inter molecule and its effects towards its characteristics and material’s condition | Energy- intra, inter molecule, and the materials’ condition |
| | P.6.11 | Apply the concept of redox on electrochemical cells | Electrochemistry |
| | P.6.12 | Apply the kinetics concept in chemical reaction | Chemical kinetics |
| | P.6.13 | Explain the concept of complex ion and coordination compounds | complex ion and coordination compounds |
THE LEARNING OBJECTIVE OF THE STUDY PROGRAM

| NO. | THE LEARNING OBJECTIVES OF THE COURSE | DISCUSSION MATERIALS |
|-----|--------------------------------------|----------------------|
| P.6.14 | Explain the concept of core chemistry and its implementation | core chemistry |

Furthermore, the second stage was drafting the HOTS questions consisting of 40 multiple-choice questions which were adjusted to the learning objectives of the study program and the learning objectives of the basic chemistry course. The results of the expert analysis of the material aspects states that the online appraisal of the Higher Order Thinking Skills (HOTS) category based on online applications is feasible to use or valid.

After drafting the HOTS question, the author moved to the last stage which was produced the HOTS questions into an online application by using IT program and was validated by several experts. The validation is intended to obtain the assessment and investigate the weaknesses of the instruments from the validators data. Then, the validators provided the suggestions for the improvement of the instrument. Notably, the suggestion would be utilized as the reference in revising the instrument to be better [13]. Likewise, the process of validation and revision were conducted several times and waited the agreement from the validators to test the instrument to the pre-service teachers. The following are the results of the validation of media experts:

![Figure 2. Media Expert Validation Results](image)

Based on the graphic figure 2 above, it can be seen that in the aspect of software usage, a value of 96.5% (very good category) is obtained. The ability aspects that can be implemented that are measured include how the indicators in the statement are: efficient in the use of the application, effectiveness in responding quickly, reliably, ease in maintaining the application, accuracy in choosing the type of application, compatibility, documentation on media usage instructions, 2) communication aspects, visual and media with indicators in statements.

The second aspect is the communication, visual and media aspects. In this aspect measured how in the form of communication, creative in ideas and capturing ideas, visuals, interactive layouts, accuracy of letter selection, and image quality in the material in the application by 91.25% (very good category).

4.2. The Data of Product Testing

The development of computer technology and testing theory had accelerated the changes in the examination formats from the conventional (paper-based) to the computer-based examination [16]. The assessment instrument on the content testing of the chemistry was one of the alternative uses of
the computer-based technology. The validated instruments would be tested to seventy pre-service teachers, who were in the fifth semester and seventh semester. This testing was carried out to know their responses towards the developed instruments.

![Figure 3. Responses of the Pre-service Chemistry Teachers](image)

Based on the graphic above, it can be said that the aspect of the implementation ability seemed to indicate in the excellent percentage for about 86.4%. It was measured from how easy to understand the procedural instructions, the usage, and its access. Further on, the second aspect was the sustainability aspect. Through this aspect, the authors measure the durability of the assessment on the content test of the chemistry higher order thinking skills, the easiness of its maintenance, and the application use. Similarly, the average percentage of the pre-service chemistry teachers indicated in 83.3%, which meant in the excellent/very good category. The third aspect was compatibility with the environment. This aspect included the flexibility use of the media without any limitation time and place as well as the media that could be used in various learning situation regarding the students’ level. Based on the responses of pre-service chemistry teachers, an average percentage showed in 91.6% (very good category). The fourth aspect is the students’ interest. This aspect included the students’ interest in exploring the general public, increasing their interest in learning, receiving media assessment, and attracting developed assessment media. Based on the responses of prospective chemistry teachers, the average percentage was 82.4% which were classified into a very good category. Overall, based on the percentage per indicator obtained in the study, the results of the development of online-based HOTS chemical content test assessment were included in the excellent category with an average percentage of 85.91%.

The assessment instruments on the content testing of the chemistry Higher Order Thinking Skills (HOTS) trough online-based application can be utilized as the evaluation media. It may help the students and the lecturers effectively and efficiently and facilitate the scoring. Sudijono [18] asserted that the factors influenced the occurrence in the scoring and evaluating process were measuring instruments, evaluators, students, and situations. Therefore, the implementation of the situation provided the information related to the learning objectives.

Importantly, the evaluation could stimulate the students to think critically and reflect about the previous materials. It meant that the evaluation might measure the involvement of the students’ collaborative thinking from the theory and its implementation [18]. Also, the use of the assessment instrument through online-based application accommodated the shallow thinking pattern and reduced the errors in the assessment process. [19]
Based on the data, the average percentage of student responses to the instrument developed was 85.91% and included in the excellent category. It meant that the application of assessment instruments could be used easily, connected to the media, the application maintenance and media durability, able to use without any limitation of space and time and increase the students’ motivation and learning interest and appropriate for use in the assessment.

5. Conclusion and Suggestion
Based on the result, it seems to indicate that the pre-service teachers’ show a good response on the assessment of the content test of the chemistry Higher Order Thinking Skills (HOTS) through online-based application with the average percentage reaches into 85.91%.
For following up the research about the assessment on the content test of chemistry higher order thinking skills (HOTS) through online-based application, it needs a further research by implementing the application in the learning process. It is aimed to examine whether the learning objectives are achieved or not.

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