Higher-order thinking skills (HOTS) in teaching and learning biology at Madrasah Aliyah

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Abstract: The study was conducted to analyze Higher-Order Thinking Skills (HOTS) in teaching and learning biology at Madrasah Aliyah in terms of planning and evaluation. Twenty-four randomly selected biology teachers from eight Madrasah Aliyah in West Lombok Regence were involved in this study. The results indicated that the teachers, in general, have not understood the planning and assessment of HOTS-based teaching and learning; 6.25% of the teaching and learning objectives was HOTS-oriented, 17.19% of the teaching and learning activities was HOTS-oriented, 5.83% of the test questions was HOTS-oriented, and all of the teachers considered HOTS very important and it became the orientation of biology teaching and learning at Madrasah Aliyah.

1. Introduction

Education should be managed well in order to be able to produce thinker resources. Students should be trained to use the power of argument, thinking skills in education because they will face rapid and challenging changes in science and technology [1]. In the 21st century, thinking skills are crucial to support economic prosperity [2]. In consequence, students deserve HOTS education, in order to equip them with the skills how to make decisions and think critically and creatively [3], and teachers need to understand how to teach in the 21st century in order to be able to provide the students with skills [1].

HOTS involves high order cognitive thinking skills which are adapted from Bloom’s Taxonomy [4]. High order thinking refers to the mental process of analyzing, synthesizing, evaluating, and producing new ideas [5, 6] and it is generally used in such activities as problem-solving, reasoning, thinking, evaluating, and drawing conclusion [5]. HOTS contains analyzing information to determine a problem, evaluating the problem, and creating a new solution which can be applied [7]. Analysis of information includes understanding facts, drawing conclusion, connecting the information with other facts and concepts, categorizing, manipulating, and combining the information with new ways [8]. Thus, the quality of identified questions and statements during the teaching and learning process needs to be enhanced in the domain of analyzing (C4), evaluating (C5) and creating (C6).

HOTS continues to undergo expansion in its dimensions; it is not limited to the skills of analysis, synthesis, and evaluation only. HOTS includes skills such as searching out order and imposing meaning on information, critical thinking, creative thinking, problem-solving, planning, decision making [9], visualization [10], and self-regulated thinking skill [11]. HOTS define as three different categories: (1) HOTS as a transfer, (2) HOTS as a critical thinking, and (3) HOTS as a problem-solving. As a transfer, HOTS is a skill of applying knowledge and it is the one trained during the teaching and learning in a new situation. As a critical thinking, HOTS is thinking, reflecting, and
making a good decision. As a problem-solving, HOTS encompasses analyzing information to determine a problem, evaluating the problem, and creating a new solution which can be applied [12]. The aspects of higher-order thinking skills are problem-solving, decision making, and creative thinking [13]. HOTS can be taught and learned, and developing HOTS is not only a matter of developing high cognitive abilities but also developing all individuals’ capacities [14]. Encouraging students to develop HOTS is a goal to be achieved by the teachers and science curriculum developers [15].

Researches conducted in Indonesia on the students’ higher-order thinking skills show synchronous results. The students’ scientific literacy are on the functional level; low literacy skill category [16], the results of test of scientific literacy skills (TOSLS) on the materials of certain natural science subjects are medium by category, affected by such factors as curriculum and education systems, selection of methods and models of teaching and learning, facilities and infrastructures, learning resources, and teaching materials [17, 18]. Researches conducted in some favorite schools wherethe students gain high average scores also reveal that the students’ competencies on HOTS are still very low [19]. Especially for higher students, they must not only have a lower order thinking, but also have to reach a higher order thinking. Most of students still have low ability, if it is seen from cognitive aspect knowing, applying, and reasoning [20].

Besides the learning outcomes, the students’ higher-order thinking skills in the teaching and learning process is still low. The students are only used to do lower order thinking activities [21]. The whole data show that the students’ high order thinking skills become a problem which should be addressed seriously in education. This study reveals how the teachers understand about HOTS concepts and planning in teaching and learning, and HOTS-based teaching and learning evaluation conducted by biology teachers in Madrasah Aliyah.

2. Methods

This was a descriptive study conducted on twenty-four biology teachers from eight Madrasah Aliyah which were selected randomly in West Lombok Regence. The study focused on three aspects, namely (1) knowledge and response of the teachers to HOTS, (2) HOTS planning in teaching and learning, and (3) HOTS implementation in the evaluation of biology teaching and learning. Data were collected through interview and documentation techniques and they were analyzed descriptively. The use of descriptive statistics in this study in the forms of average, percentage, and graphs helped to draw conclusions.

3. Results and Discussion

3.1. Teachers’ knowledge about HOTS

Preliminary exploration of the teachers’ knowledge of high order thinking skills was the first thing to do in this study. The next was to come into the main concern of this study, namely how was HOTS in teaching and learning biology at Madrasah Aliyah. The knowledge of biology teachers about HOTS related to some aspects; intention, link between HOTS and the demand of the 21st century, HOTS aspects, and HOTS implementation in teaching and learning. Based on the results of structured interviews with 24 teachers, the data obtained were as in the following table.

| No. | Aspects of HOTS | Knowledge | Percentage (%) |
|-----|-----------------|-----------|----------------|
| 1.  | Intention       |           | 21             |
| 2.  | Relation to the 21st century | | 17             |
| 3.  | Aspects         |           | 17             |
| 4.  | Implementation in teaching and learning; planning, classroom environment, instructional activities, tasks characteristics, and assessments. | | 8              |
The table showed that most of the biology teachers at Madrasah Aliyah in West Lombok Regency did not have knowledge of the HOTS concepts and its implementation in teaching and learning. There were the teachers who just heard the term HOTS when questions about HOTS were asked to them. Even so, the teachers understood the dimensions of the thinking process C1 to C6. Theoretically, they also understood that teaching and learning should be planned and implemented through active learning approaches. The teachers' lack of knowledge regarding the HOTS concepts caused the planning, implementation, and assessment of teaching and learning unsuccessful to develop the students' higher-order thinking skills. The quality of teaching and learning depend on what the teachers understood and performed [22]. Teachers play a critical role in foregrounding and integrating HOTS [23], what the teacher performs in the class ultimately form the type of teaching and learning the students gained [22].

Under the condition of lack of knowledge about the HOTS concepts, all the teachers considered HOTS very important to be the orientation of teaching and learning biology at Madrasah Aliyah. They have a positive view of the implementation of HOTS in teaching and learning because it is beneficial to their real life [24]. The absence of specific education and training regarding HOTS caused the teachers not to understand and apply the concepts in teaching and learning, although in the teaching and learning plan documents and the test items they compiled contain teaching and learning objectives and activities, and the test items containing HOTS were not well planned.

3.2. HOTS Planning in Learning
Although this study revealed that 21% of the sample had knowledge about HOTS, the study about documents related to biology teaching and learning plan for all samples remain to be done. HOTS-oriented teaching and learning plan was obtained from the teaching and learning implementation plan (RPP) document developed by the teachers. HOTS planning aspects in teaching and learning included a decision about teaching-learning objectives and activities. The teaching and learning objectives developed by the teachers were classified based on the cognitive levels of Anderson and Krathwohl's taxonomy. The results of the study were presented in the following figure.

![Figure 1. Portion of the dimension of the thinking process in the teaching-learning objectives](image)

The figure above indicated that high order thinking skills-oriented teaching and learning objectives (C4, C5, C6) were only 6.25%. Thus, it can be said that the orientation of biology teaching and learning at Madrasah Aliyah in West Lombok Regency still focus on lower order thinking skills.

In the aspect of teaching and learning activities plan, some of the students' activities designed by the teachers were observing pictures/objects, reading/studying, analyzing problems, asking questions based on observations, recording important things, planning problem-solving, listening to the teachers' explanation, demonstrating/modelling, answering questions, conducting investigations/experiments, solving problems, analyzing, concluding, designing, creating, conveying ideas, presenting, reflecting. Each activity was carried out with different intensities in every meeting. Based on the results of
analysis of the teaching and learning implementation planning document developed by the teachers, it was obtained the data about the students’ activities plan as in the following table.

### Table 2. Portion of the students’ activities on biology teaching and learning plan

| No. | Teaching and Learning Activities | Percentage (%) |
|-----|---------------------------------|----------------|
| 1.  | Observing objects               | 87.50          |
| 2.  | Reading/studying                | 100            |
| 3.  | Asking questions based on observation | 25           |
| 4.  | Recording important things      | 100            |
| 5.  | Listening to the teachers’ explanation | 100       |
| 6.  | Demonstrating/imitating/modelling | 50            |
| 7.  | Answering questions             | 100            |
| 8.  | Analyzing problems              | 12.50          |
| 9.  | Planning to solve problems      | 0.00           |
| 10. | Solving problems                | 0.00           |
| 11. | Conducting investigation/experiment | 37.50     |
| 12. | Analyzing the results           | 37.50          |
| 13. | Concluding based on data        | 12.50          |
| 14. | Designing/creating              | 25.00          |
| 15. | Conveying ideas                 | 12.50          |
| 16. | Concluding lesson materials     | 100            |
| 17. | Presenting/communicating        | 37.50          |
| 18. | Reflecting                      | 25             |

The table showed that the students’ activities which were planned related to HOTS (numbers 8-15) are very small, on the average of 17.19%. These activities are still categorized into lower-order thinking skills (LOTS). The activities of solving complex problems in everyday life up to creating something were not planned in teaching and learning. The activities were carried out maximally in two meetings in each semester. The activities the students always carried out in each meeting were reading/studying textbooks, recording teachers explanations, answering questions, and summarizing lesson materials during the post activities.

Viewing from the aspects of teaching and learning plan, the teachers really planned the teaching and learning with different strategies such as directive Instruction, group discussion, cooperative learning, discovery learning, inquiry, question and answer, assignment, and problem-based learning. However, when the teaching and learning activities were examined, the components of the teaching and learning steps did not emphasize the activities which required the students to solve complex problems and to design something to solve the problems. These teaching and learning plan may have facilitated the students’ ability to improve test scores, but they do not make a real contribution to the development of their scientific reasoning and deep understanding [25]. The intended problems posed by the teachers which would be solved by the students was a number of questions given by the teachers which demanded the students to look for answers in groups or independently and then the answers were presented in front of the class. Appropriate teaching strategies and learning environments which facilitate growth in thinking level often leads to reasoning, evaluating, problem-solving, decision making and analyzing situations. Teaching skills order thinking skills are when the students; visualize a problem by diagramming it, separate relevant information from problems, looking for reasons and causes, justifying solutions, revealing assumptions in reasoning, and identifying bias or logical inconsistencies [26, 27].
3.3. HOTS-Based Tests
Analysis of the test questions for mid-term (UTS) and final examination (UAS) at the schools where the preliminary study was conducted showed that the skills demanded were still low order thinking.

![Figure 2. Portion of the thinking process dimension in the final test](image)

The figure showed that the test questions developed by the teacher at Madrasah Aliyah in West Lombok Regency had a small portion of the students' high order thinking skills. On the average, 5.83% of the test items given were HOTS-oriented. Most of the items tested on the students were only lower order thinking skills-oriented. The fact implied that higher-order thinking skills as the orientation of skills in the 21st century have not yet become a serious concern in teaching and learning biology at Madrasah Aliyah in West Lombok Regency. Unknowingly, biology teaching and learning which are planned and carried out only emphasizes on lower order thinking skills. This lack of knowledge of HOTs may eventually lead to teachers' inability to assess the students' HOTS [28], though the assessment for learning proved that it helps to develop the student's thinking skills [29].

4. Conclusion
In general, biology teachers at Madrasah Aliyah in West Lombok Regency do not understand the planning and evaluation of HOTS-based teaching and learning, 6.25% of the teaching and learning objectives is HOTS-oriented, 17.19% of the teaching and learning activities is HOTS-oriented, 5.83% of the test questions is HOTS-oriented and all of the teachers consider HOTS very important to be the orientation of biology teaching and learning at Madrasah Aliyah.

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