

The Learning Management of Mathematics Based on Higher Order Thinking Skills in Senior High School

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Abstract—This study aims at describing the learning management of Mathematics based on Higher-Order Thinking Skills (HOTS) among twelfth grade of senior high schools throughout Bantul Regency. This study can be categorized as quantitative research which was conducted on 19 schools in Bantul Regency. It was done from May to August 2019. The source of the data was syllabus documents, student worksheets, and daily questions, midterm and end of semester exams for Mathematics twelfth grade of senior high schools throughout Bantul Regency. The data collection techniques used document studies. The data analysis techniques employed quantitative data analysis with percentages. The results reveal that there has been 82.5% of HOTS based-learning management of Mathematics among the twelfth grade of state senior high schools in Bantul Regency but the percentage tends to decrease during the learning implementation (54.4%) and learning evaluation (58.3%) respectively.

Keywords—learning management; high order thinking skills.

I. INTRODUCTION

The 2013 curriculum demands students not only to have good attitudes and knowledge but also reasoning, processing, and working skills that creative, productive, critical, independent, collaborative, and communicative in the concrete and abstract domains. The learning in the 2013 curriculum is directed to facilitate students to be able for observing, asking, trying, reasoning, presenting and creating. It urges the teachers to create the learning process which is interactive, inspiring, fun, challenging and motivating based on the students' physical and psychological development.

Various learning models have been promoted to optimize the students' learning and to develop their thinking skills. One of the popular models in the 2013 curriculum is Problem Based

Learning (PBL). The PBL model according to Cazzola is a learning approach that emphasizes students' constructivism through analysis, resolution, and discussion on the given problems [1]. Susanto argues that thinking skills can be developed with special treatment to train the thinking process to store long-term memory so that the obtained knowledge will be more meaningful [2].

HOTS related to the demands of thinking skills in the 2013 curriculum is in line with Krathwohl's opinion who adopted Bloom's taxonomy of learning domains that categorize the indicators to measure higher thinking skills including analyzing, evaluating and creating. In details, (1) analyzing refers to students' skills to separate problems into its constituent parts and to detect how each part is related one another; (2) evaluating is students' skill in decision making based on the standard criteria (3) creating means students' skill in planning a design to complete a given task [3].

The level of thinking ability which is divided from low into high levels is part of Bloom domains or called the cognitive domain. The other two domains of affective and psychomotor have their own levels. This cognitive domain has been revised into (1) remember; (2) understand; (3) apply; (4) analyze; (5) evaluate, and (6) create. The level 1 to 3, according to the initial concept, are categorized as Low Order Thinking Skills (LOTS), while 4 to 6 included as Higher-Order Thinking Skills (HOTS).

HOTS-based learning has actually been introduced along with the implementation of the 2013 curriculum, but in reality, there appears a lack of understanding in which many teachers find it difficult to make HOTS-based exercises. The learning process carried out by teachers also do not stimulate high levels thinking ability. Actually, the teacher has attended training to support students' ability to have high order thinking skills.

However, the training is dominated by theoretical activities about HOTS without real examples and practice. It makes teachers experiencing difficulties or confusion to implement HOTS in their teaching process.

Based on the National Examination results (www.puspendik.kemdikbud.go.id/hasilun) especially for Mathematics, there was a significant decrease of 54.21 in the school year of 2017/2018 which previously reached an average of 56.86 in 2016/2017. Basically, the efforts from Ministry of Education and Culture to raise the difficulty level of the questions items in National Examination based on HOTS questions are to enhance the students' analytical and critical thinking skills. It is also to implement character education to develop students' perseverance and seriousness in solving problems. It means teachers must be able to create challenging and fun learning conditions to effectively improve students' knowledge and skills.

To train thinking skills, it is basically based on two philosophies. Firstly, there must be special materials or lessons about the thinking process. Secondly, it integrates thinking activities in each learning activity. Thus, thinking skills especially high-level thinking must be developed and become part of everyday lessons. With this approach, thinking skills can be enhanced by helping students to become better problem solvers. For this reason, teachers must provide problems (questions) that enable students to use their high-level thinking skills.

A number of basic skills for teachers in managing learning have been conveyed by Allen & Ryan including the ability (a) to start lessons, (b) to provide stimulus, (c) to propose questions, (d) to use cues, (e) to use illustrations/ examples, (f) to communicate, (g) to provide reinforcement or feedback, and (h) to end lessons [4]. These various capabilities need to be continuously trained and strengthened for both prospective and in-service teachers in order to create professional teachers. During the learning process, teachers implement the learning process that has been prepared in the lesson plan. In the 2013 curriculum, teachers are expected to apply the scientific approach consisting of (1) observing, (2) asking, (3) collecting information, (4) reasoning associating, and (5) communicating. These five things are not systematic and must be existed in every learning activity which is adjusted to the situation, conditions, and characteristics of the subject matter. By doing so, the application of the scientific approach is expected to be able to realize HOTS-based learning.

As teachers, they must apply the model or method that has been set in the lesson plan. In fact, most teachers use the method of lecturing. Indeed, the lecturing method cannot be ruled out in the learning process, but teachers are expected to use more varied models and methods in order to promote cooperation, communication, collaboration, creativity, and innovation during learning process as well as to build critical thinking, and problems solving skills in accordance with 21st century competency demands.

This study aims at describing the HOTS based-learning management of Mathematics in the twelfth grade of senior high schools throughout Bantul Regency. There are some definitions of higher-order thinking skills (HOTS) proposed by experts.

Resnick defines HOTS as a complex thinking process to break down materials, make conclusions, build representations, analysis, and build relationships by involving the most basic mental activities [5]. This skill is also used to underline various high-level processes according to Bloom's taxonomic level. According to Bloom, skills are divided into two parts. The first is low-level skills that are important in the learning process, i.e. remembering, understanding, and applying, while the second is classified into higher-level thinking consisting of analyzing, evaluating, and creating

II. METHODS

This study can be categorized as quantitative research which was conducted on 19 schools in Bantul Regency. It was done from May to August 2019. The source of the data was the Mathematics teacher and the data collection techniques used document studies. The data analysis techniques employed quantitative data analysis with percentages.

III. RESULT AND DISCUSSION:

A. Learning Plan

The following summarizes the data through documents study on the syllabus of Mathematics in the twelfth grade of senior high schools in Bantul Regency.

TABLE I. SUMMARY OF DATA ANALYSIS OF MATHEMATICS SYLLABUS

No.	Question items	Option	%
1.	Is the formulation of core/basic competency of the knowledge dimension in the HOTS area (analyzing, evaluating, and creating)?	YES	85,3%
		NO	14,7%
2.	Does the learning approach use a scientific approach (observing, asking, gathering information/ trying, associating/ processing information, and communicating)?	YES	79,4%
		NO	20,6%
3.	Does the learning process develop 4C skills (creative, critical thinking, collaboration, and communication)?	YES	72,7%
		NO	26,5%
4.	Does the use of the learning model shape scientific behavior (eg discovery/ inquiry learning, problem-based learning, or project-based learning)?	YES	92,7%
		NO	7,2%
Average			82,5%

Based on Table 1, it is known that:

- 1) Most of the aspects (50% <) in the core/basic competency in the syllabus of Mathematics were in the HOTS area, i.e. C4, C5, and, C6 levels.
- 2) More than 50% of the learning approaches designed in the syllabus of Mathematics used the scientific approach (observing, asking questions, gathering information/ trying, associating/ processing information, and communicating).

3) More than 50% of the learning process designed from the syllabus of Mathematics had developed the ability of 4C (creative, critical thinking, collaboration, and communication).

4) More than 50% of the learning models that were designed in Mathematics syllabus could shape scientific behavior, for example, discovery/inquiry learning, problem-based learning, or project-based learning).

The formulation of core and basic competencies plays a crucial role in achieving the learning outcomes of the HOTS model. The HOTS area is in the levels of C4, C5, and C6. The core and basic competencies are directed in the learning activities that require students to think critically by making and choosing questions that will trigger them to have critical thinking process. The students need to be trained to think critically through: 1) critical reading, 2) critical reading, and 3) critical answering.

The stages of critical thinking according to Thyer are [6]:

- 1) Observation, i.e determine, obtain, confirm, explore, and identify information from various sources.
- 2) Analysis, i.e. scrutinize information into main themes or arguments.
- 3) Evaluation, i.e. discriminate values, differentiate opinions and facts and prioritize important information.
- 4) Contextualization, i.e relate to history, ethics, politics, culture, and environment.
- 5) Asking questions, i.e. consider possible alternatives and develop new hypotheses.
- 6) Reflective, i.e. test conclusions and anticipate the impact that might occur.

Based on the above opinion, there were 85.3% of the core and basic competencies in Mathematics subjects which can be categorized in the HOTS area. It means that the teachers have applied the basic skills in critical thinking related to problem-solving. It is an alternative solution by analyzing the causes of the problems through mind mapping.

Critical thinking can also be done through mind mapping based on brainstorming. To measure the students' ability in problem analysis in Mathematics, the technique of 5W (Who, What, Why, When, Where) and 1H (How) questions can be used in order to find its alternative solutions.

In terms of the learning approach designed in the syllabus from four subjects of Mathematics, there were more than 50% that used the scientific approach, i.e. observing, asking questions, gathering information, processing information and communicating. It indicates that the students' critical thinking needs to be built in two ways to produce creativity, extensive knowledge (several fields of science) and mastering one or two fields in depth. According to Batey & Furnham there are three main domains of creative expression, namely artistic, scientific, and daily creativity [7]. The scientific creativity can be seen from one's ability to construct hypotheses, design experiments and investigate facts. It is carried out based on divergent exploration (multiple responses in a challenge) and integrative convergent of thinking processes (the single most creative responses).

In terms of the learning process, 50% of the syllabus of Mathematics subjects had developed 4C abilities (Creative, Critical Thinking, Collaboration, and Communication). It emphasizes the importance among teachers to stimulate students to have active thinking in which HOTS-based learning directs teachers as facilitators to facilitate students to think. Therefore, the teachers need to prepare assignments or question items that can make students have critical thinking and problem-solving. The learning activities with inquiry approaches can make students able to formulate problems and those are in accordance with HOTS-based learning. Inquiry-based learning can foster students' independence in learning and make them actively investigate or learn to solve problems towards relevant and meaningful issues. The student involvement in inquiry-based learning will enhance the ability to explore knowledge or discover new knowledge.

The students are also trained to have the ability to solve contextual problems related to various fields of science. Cooperative and collaborative learning allow them to think critically. As emphasized by Thayer-Bacon on the importance of relationships among others to realize critical thinking [8]. It is in line with the opinion from Bailin, Case, Jerrold, Coombs, & Daniels that critical thinking includes the ability to give positive responses to others during group discussions [9].

In terms of the learning model, the data shows that only can the learning models of chemistry shape scientific behavior using discovery/inquiry learning. Discovery of learning refers to a cognitive learning method that requires teachers to be more creative in creating situations that can make students actively learn in developing their own knowledge. According to Bruner, the discovery method suggests that students learn actively to develop concepts and principles through experimental activities so that students simultaneously develop their knowledge and skills. In this case, the Chemistry course is dominated by experiments activities in the laboratory that requires teachers help in developing concepts. It means that the discovery activity needs supervision from the teacher to gain concepts and theories among students. The discovery learning can be combined with inquiry by proposing a hypothesis on an experiment in Chemistry learning.

B. Learning Implementation

The following presents the data through documents study from Mathematics worksheets among the twelfth-grade students of senior high schools in Bantul Regency.

TABLE II. THE SUMMARY OF DATA ANALYSIS ON THE STUDENTS' WORKSHEET IN MATHEMATICS

No.	Question items	Option	%	Explanation
1.	Does the teaching material contain elements of facts, concepts, principles, and procedures?	YES	66%	principles, concept
		NO	34%	-
2.	Do the questions in the worksheet measure the ability to think at a higher level (analyze, evaluate, and create)?	LOTS	66%	C3: counting, determining,
		HOTS	34%	-
3.	Are the questions in the worksheet based on contextual problems (real-world context)?	YES	34%	discourse
		NO	66%	-
4.	Do the questions in the worksheet have proper stimuli (information at the beginning of the case, for example, pictures, graphics, and discourse)?	YES	84%	graph, table, discourse, picture
		NO	16%	-
Average		82,5%		-

Based on Table 2, it can be seen that the worksheet of Mathematics shows the following points.

- 1) There were 66% of the exercise in Mathematics worksheet still in the LOTS C3 level which could be indicated by the use of verbs like counting and determining.
- 2) Only 34% were the problem question items of Mathematics Subjects based on contextual problems (real-world context), as preceded by discourse and the rest (66%) were not based on the contextual situation.
- 3) There were 84% of the questions in the worksheets that had proper stimuli with the problem (information at the beginning of the case, for example, pictures, tables, graphics, and discourse).

The implementation of the learning process refers to a situation where a dialogic process occurs among the learning environment, learning resources, teachers, and students. This process requires strategies, methods, and learning media which are relevant to the objectives to be achieved, the teaching materials, and the students' characteristics. One component needed for the implementation of learning is the learning resource that can be in the form of textbooks, modules, and handouts. Moreover, the students' worksheets contain the learning resources that are arranged to achieve the specific learning goals which contain material (usually shorter than textbooks) completed with exercises.

The student worksheets were chosen in this study because they represent the teaching methods and materials delivered in the learning process. Based on the results of the study, it was found varied results among the courses being studied. For example, 66% of the Mathematics worksheet was still on the LOTS level.

The transfer of teaching material should be adjusted to its nature, as a product, process, and scientific attitude, so it is expected that scientific attitude will also be formed on students. The application of several learning models based on HOTS needs to be done through various learning models that stimulate students to develop their scientific attitudes. Project-based learning, problem-based learning, discovery/ inquiry learning provides opportunities for teachers to implement learning activities in the HOTS level. However, in practice the application of HOTS learning is not an easy thing for most teachers. Besides, the teacher must really master the material and learning strategies, and they are also faced with challenges with the environment and the input of students.

C. Learning Evaluation

The following presents the data through documents study from the Mathematics assessment among the twelfth-grade students of senior high schools in Bantul Regency.

TABLE III. THE SUMMARY OF DATA ANALYSIS ON DAILY /MID/FINAL EXAM OF MATHEMATICS

No.	Questions	Option	%	Explanation
1.	Do the questions items of the daily/ mid /final exam measure HOTS?	LOTS	72,2%	C3: counting, ordering
		HOTS	24,8%	C4: solving, measuring, associating, analyzing
2.	Are the daily/ mid /final exams based on contextual problems (real-world context)?	YES	66,7%	case
		NO	33,3%	-
3.	Do the questions item of the daily/ mid /final exam have stimuli that are in accordance with the problem (information at the beginning of the problem, for example, tables, cases, pictures, and graphics)	YES	41,7%	case
		NO	58,3%	-
4.	Are the questions items of the daily/ mid /final exam compatible with basic competency?	YES	100%	-
		NO	0%	-
Average			58,3%	-

It can be seen from Table 3 on the daily/ mid /final exam in Mathematics subject shows the following points.

- 1) There were 24.8% of the question items in the daily/mid/final exam in the HOTS C4 level, which could be indicated from the use of verbs: solving, measuring, associating, and analyzing, while the rest (72.2%) are in the C3 LOTS level with verbs including counting and sorting.
- 2) There were 66.7% of the question items in the daily/mid/final exam based on contextual problems

(real-world context) which were preceded by a case or discourse.

- 3) Only 41.7% had the daily/ mid /final exams of Mathematics stimuli that were in accordance with the problem, in the form of a case or discourse, while the rest (58.3%) have no stimuli in accordance with the problem.
- 4) It was 100% the daily/ mid /final exams of Mathematics based on Basic Competence contained in the syllabus.

The learning reform is carried out by changing/shifting traditional LOTS-based learning into HOTS-based learning. According to Gelven & Stewart schools must train higher-order thinking skills as an effort to prepare graduates with the working challenge and lifelong learning [10]. The data showed that daily/mid/final exam in Mathematics course was 24.8% in HOTS C4 level, 66.7% was based on contextual problems (real-world context), 41.7% had stimuli that were in accordance with the questions in the form of cases or discourse and 100% was based on the Basic Competence contained in the syllabus. The HOTS form must meet several criteria, especially the questions that are used to assess critical thinking skills. Paul & Nosich test the ability to think critically by making a list of several statements and asking test-takers to choose the type of statement, essay questions, questions with rating scale (multiple rating) [11].

Killoran states that critical thinking tests can be made in the form of multiple choices related to databases and standards [12]. The questions based on data refer to the data provided on the question items. For example, the item of knowing the terms and/ or people, comparing/ contrasting, cause and effect, chronology, distinguishing facts from opinions. Sugrue, Buist, Lee, Sanchez, & Hillman) mentions that questions created to assess critical thinking skills should be open-ended questions or tasks, authentic with the real world, and less structured problems [13]. The students make reasoning by providing evidence or logical arguments to support decisions, choices, claims or demands.

Based on the data on daily/ mid/ final exam in Mathematics, there were 72.2% in the LOTS level, 66.7% were based on contextual problems (real-world context), 100% were in accordance with Basic Competence contained in the syllabus, but 41.7% did not have stimuli that were in accordance with the problem whether in the form of cases, tables, figures, or discourse. Another HOTS criterion is the question item to assess creative thinking and the Torrance test is commonly used in research and learning. This test takes the form of a picture creation or sentence description and it is usually used to measure students' critical thinking skills.

Making the HOTS based-test items with critical thinking criteria involves recognizing the problem, defining the problem, explaining the meaning through careful observations, looking for alternative solutions with mind mapping, deductive thinking, inductive thinking, and differentiating between arguments and explanations. In addition, teachers must also be able to make questions that are in accordance with the needs of problem-solving both the models and the learning strategies.

IV. CONCLUSION

Based on the research results, there has been 82.5% of HOTS based-learning management of Mathematics among the twelfth grade of state senior high schools in Bantul Regency but the percentage tends to decrease during the learning implementation (54.4%) and learning evaluation (58.3 %) respectively.

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