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# Optimization of Achievement in Chemistry Learning Outcomes by Implementing Discovery Learning-Based Strategy

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***Abstract*— Efforts to optimize the achievement of chemistry learning outcomes are carried out through experimental research by implementing discovery learning strategies for high school students in Mataram and West Lombok Regency. This study specifically aims to examine the effect of the implementation of discovery learning on higher-order thinking skills (critical and creative thinking skills) and students' chemistry learning outcomes. The study population consisted of 131 students and 85 students from one of the public high schools in Mataram and West Lombok Regency, respectively. The sample was determined by purposive sampling, where the number of students selected as a sample from SMA in Mataram was 66 students and the sample from West Lombok Regency were 64 students. In each SMA as a sample, one experimental class and one control class are assigned. In the experimental class, discovery learning is applied, while in the control class, conventional (expository) learning is applied. The data were obtained based on the test results and analyzed using the two difference test with a significance level of 5%. Based on the results of research and data analysis, it is concluded that the implementation of discovery learning strategies has a positive effect on critical thinking skills, creative thinking skills, and chemistry learning outcomes of public high school students in Mataram and West Lombok Regency.**

***Keywords*— *Discovery learning, critical thinking skills, creative thinking skills, the results of studying chemistry.***

## I. INTRODUCTION

Learning that is emphasized in the 2013 curriculum is learning by empowering high-order thinking (HOT) [1]. Teachers as the spearhead of change can change the mindset and learning strategies that were originally teacher-centered to student-centered. Teachers are expected to be more creative and innovative in presenting subject matter. Learning that can be applied is learning by empowering high-order thinking.

The government expects students to achieve various competencies by implementing HOTS (high order thinking skills) or high-level thinking skills. HOTS is a thinking skill that includes logical, critical, reflective, metacognitive, and creative thinking. Higher order thinking skills consist of logical thinking, critical thinking and reasoning abilities which are basic abilities in everyday life, regardless of academic achievement [2]. These competencies are critical thinking, creative and innovative, communication skills, collaboration skills and confidence.

Facione [3] defines critical thinking as thinking that has the aim of proving a thing, interpreting certain purposes, solving problems in order to make the right decisions. Hartati [4] defines that critical thinking is logical and reflective thinking that is focused on what decisions are believed and carried out. According to Enis [5], critical thinking is thinking that is reasonable and reflective which focuses on determining what to believe or do.

Based on the definition of critical thinking, according to some experts, it can be concluded that the ability to think critically is the ability to think logically in interpreting the intention or problem so that it can make the right decision. There are 5 (five) indicators of critical thinking skills as stated by Robert Ennis [5], namely: (1) providing simple explanations, (2) building basic skills, (3) concluding, (4) providing further explanations, and (5) set strategy and tactics.

The ability to think creatively is an ability that reflects fluency, flexibility and originality in thinking as well as the ability to elaborate on an idea [6]. Rogers [7] defines creativity as a process of bringing new results into action. It can be concluded that the ability to think creatively is the ability based on available data or information, to find many possible answers (divergent thinking) to a problem where the emphasis is on quantity, efficiency and a variety of answers. Indicators of creative thinking skills in this study consist of flexible thinking skills, original thinking skills, detailed thinking skills, and fluent thinking skills [6].

Chemistry is a part of natural science that takes matter as an object. The purpose of chemistry subjects in SMA / MA is that students have the ability to understand chemical concepts, principles, laws, and theories as well as their interrelation and their application to solve problems in

 

everyday life and technology. Another goal of chemistry subjects in SMA / MA is to cultivate a scientific attitude that is honest, objective, open, resilient, critical, and able to work with others [8].

The achievement of studying chemistry in high school which is observed from year to year is generally in the low category compared to the learning achievement of other science subjects [9]. Even in the 2019 national exam, when students were free to choose one of the science subjects as one of the compulsory national exam subjects, very few students chose chemistry subjects. There are several factors that are thought to be the cause of the low learning achievement of students in chemistry, including: (1) learning chemistry is still more emphasized on memorizing material in the form of facts, concepts, and principles that are presented directly by the teacher by referring to the book - textbook; (2) students have not been given many opportunities to do direct experience in order to build knowledge; (3) students are still not given the opportunity to learn to find the knowledge they need on their own; and (4) in the learning process, teachers rarely provide opportunities for students to practice problem solving skills by utilizing real problems or chemical objects around students as learning resources, and (5) teachers have not applied many models. Learning that integrates learning to improve higher order thinking skills (HOTS).

The learning model is a whole series of teaching material presentations which includes all aspects before, during and after learning by the teacher as well as all related facilities that are used directly or indirectly in the teaching and learning process. In this study, the implementation of discovery learning in chemistry learning was developed by utilizing appropriate learning media. The discovery learning model emphasizes the discovery of previously unknown concepts or principles through the stages of investigation, through observing phenomena (stimulation), identifying problems, collecting data, analyzing data, verification, and generalization [10].

Therefore, through discovery learning, students are expected to be able to identify problems from natural phenomena around them, collect data / information, analyze data, and conclude their findings. Through the learning stages above, students are expected to be able to improve higher-order thinking skills (HOTS), such as the ability to think critically and creatively. It is hoped that the increase in HOTS will at the same time trigger an increase in chemistry learning outcomes.

## II. METHODS

This study used an experimental research method which is defined as a research method used to find the effect of certain treatments on others under controlled conditions [11]. This type of experimental research used is a quasi-experimental design, in this design the variables that appear and the experimental conditions cannot be controlled strictly or fully.

This research was conducted at Public Senior High Schools in Mataram and Public High Schools in West Lombok Regency. The choice of the location of this study was intended to test the learning model studied at two public high schools with different situations and conditions. The study population consisted of 131 students and 85 students from one of the public high schools in Mataram and West Lombok regency, respectively. The sample was determined by purposive sampling, where the number of students selected as a sample from SMA in Mataram was 66 students and the sample from West Lombok Regency was 64 students. Each sample group was divided into two, namely the experimental class and the control class. Both classes have equal student character based on the information that students are randomly assigned to the two classes.

The research design in each school was based on the homogeneity of the students' initial abilities as presented in Table I and Table II.

Table I. RESEARCH DESIGN IN PUBLIC SENIOR HIGH SCHOOLS IN MATARAM

| **Class** | ***Pre-test*** | **Treatment** | ***Post-test*** |
|---|---|---|---|
| Experiment | Yes | Learning with Discovery | Yes |
| Control | Yes | Learning with Conventional Model | Yes |

Table II. RESEARCH DESIGN IN PUBLIC SENIOR HIGH SCHOOLS IN WEST LOMBOK REGENCY

| **Class** | ***Pre-test*** | **Treatment** | ***Post-test*** |
|---|---|---|---|
| Experiment | - | Learning with Discovery | Yes |
| Control | - | Learning with Conventional Model | Yes |

The group treated with the discovery learning model was called the experimental group (experimental class) and the group treated with the conventional learning model was called the control group (control class). Data from each class were obtained through tests of critical thinking skills, creative thinking skills, and chemistry learning outcomes in accordance with the applied research design.

Data analysis was performed by comparing the two means of each study group using SPSS version-20. The conclusion of the data analysis results is set at the 5% significance level.

## III. RESULTS AND DISCUSSION

### The results of research at the State Senior High School in Mataram

The results of the research at SMA Negeri in Mataram were obtained through pre-test and post-test before and after the students took part in learning on the subject matter of Stoichiometry. Stoichiometry is a subject in chemistry that involves the relationship of reactants and products in a chemical reaction to determine the quantity of each substance that reacts [12]. This material discusses the concept of moles, content of substances in a compound, determination of products, and the results of a reaction.

Students' critical thinking skills in the experimental and control classes were obtained from the pre-test and post-test results using 5 essay questions based on five indicators of critical thinking skills, namely: (1) providing simple explanations, (2) building basic skills, (3) concluding , (4) providing further explanation, and (5) arranging strategies and tactics. This test aims to measure the critical thinking ability of each individual and class group before being given treatment (pre-test) and after being given treatment (post-test).

Analysis of the data obtained the results of the normality test of the N-gain data, the students' critical thinking ability in the experimental class was not normal and the variance of the two data was homogeneous, so the first hypothesis test was carried out using the Mann Whitney U difference test. is below the 0.05 significance. Therefore it is concluded that there is a difference in N-gain for critical thinking skills between the experimental and control classes. Thus it can be said that there is a positive influence on the implementation of the guided discovery learning model on the critical thinking skills of public high school students in Mataram [13].

Student cognitive learning outcomes data were obtained from the pre-test and post-test activities using 5 essay questions in accordance with KD "Applying the concept of relative atomic mass and relative molecular mass, reaction equations, basic laws of chemistry and the concept of moles to solve chemical calculations". Chemistry learning outcomes show that most students in the experimental class are in high and medium N-gain learning outcomes, while students in the control class are in low and middle N-gain score.

Based on the results of the Mann Whitney U difference test, it was found that the calculated significance was 0.000, which was below the 0.05 significance. The results of the Mann Whitney U difference test show that there is a difference in the average N-gain for chemistry learning outcomes between the experimental and control classes. Thus, it can be said that there is a positive influence on the implementation of the guided discovery learning model on the learning outcomes of students in junior High School at Mataram [13].

**The results of research at the State Senior High School in West Lombok Regency**

The results of research at the State Senior High School in West Lombok Regency were obtained through a post-test after students took part in learning on the subject matter of Stoichiometry. This study measures students' creative thinking skills and chemistry learning outcomes on stoichiometric material. The creative thinking ability studied contains four indicators, namely the ability to think flexibly, think originally, think in detail, and think fluently.

The data analysis showed that the results of the normality and homogeneity test of the students' creative thinking ability obtained that both data were normal and homogeneous, so the hypothesis testing was carried out using the t-test mean difference. Based on the results of the t-test, it was found that the t-count was 10,699 with a significance value of 0.000, which was below the significance level of 0.05. Therefore it is concluded that there is a difference in the average post-test creative thinking skills between the experimental and control classes. Thus it can be said that there is a positive influence on the implementation of the guided discovery learning model on the creative thinking abilities of state high school students in West Lombok Regency [14].

The learning outcome test given to students is a written test in the form of a description consisting of 5 questions. The basic competencies assessed are KD 3.10 and 4.10 which contain the "stoichiometry" material. The results of the normality and homogeneity tests of the two post-test data on students' chemistry learning outcomes obtained that both data were normal and homogeneous, so the second hypothesis test was carried out using the t-test mean difference. Based on the results of the t-test, it was found that the t-count was 11.007 with a significance value of 0.000 which was below the significance level of 0.05. Therefore it is concluded that there is a difference in the average post-test results of learning chemistry between the experimental and control classes. Thus, it can be said that there is a positive effect of implementing the guided discovery learning model on the chemistry learning outcomes of public high school students in West Lombok Regency [14].

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Implementation of discovery learning changes passive learning conditions to be active-creative [15]. Students are required to collect information, compare, categorize, analyze, integrate, reorganize, and conclude. According to Jerome Bruner [16], discovery (discovery) is a learning method that encourages students to ask questions and draw conclusions from general principles of practical examples of experience.

The guided discovery learning model provides opportunities for students to be active in discovering principles or knowledge through experiments and scientific methods, so that lessons will be more meaningful for students. Sumartini [17] in his research revealed that the concepts obtained by students through discovery activities in guided discovery learning will last longer in their memory. This statement is supported by the results of research by Qurniati et al. [5] in her research that the covered learning model provides broad opportunities for students to seek, discover and formulate concepts and principles through their own mental processes.

Students' critical thinking skills are more developed through the implementation of the guided discovery model compared to the conventional model because the steps in the guided discovery learning model, such as stimulation, identifying problems, formulating hypotheses ( arrange hypothesis), data collection (data collection), data processing (data processing), verification, and drawing conclusions (generalization), make students more active in the learning process so as to enable students to be able to master indicators of critical thinking skills. The results of previous research conducted by Purwanto [18] showed that the guided discovery model can improve students' critical thinking skills in physics subjects. Noor [19] in his research also stated the same thing, that the discovery learning model can improve students' critical thinking skills including interest in asking questions, the ability of students to apply concepts in different ways to a problem, and the ability of students to solve problems in different ways.

The results of data analysis showed that there was a positive effect of the implementation of the guided discovery learning model on the learning outcomes of students in junior high school at Mataram. The results of this study are in line

with research conducted by Udo [20], that the guided discovery model is more effective in improving chemistry learning outcomes than the conventional model. These findings are thought to be related to the students' critical thinking ability in the experimental class better than the control class, especially on the indicators of critical thinking skills 2 and 3, namely building basic skills and concluding. Guided discovery learning, students are guided to find answers to questions or solve problems given at the problem statement stage through collecting data / information and discussing it so that conclusions can be obtained on questions / problems previously asked. According to Muntari et al. [21], critical thinking skills and learning outcomes can be improved through brain-empowering learning. Guided discovery learning is in accordance with learning with a constructive approach [22].

Although the implementation of guided discovery learning has shown better results than conventional learning, the implementation of guided discovery learning has not achieved optimal learning completeness. Therefore, it is necessary to have a learning habit using the guided discovery model in public high school students in the of Mataram. This is in accordance with Pavlov's theory [23] that learning is a process of change that occurs due to training and repetition.

Based on the findings above, the implementation of the guided discovery learning model has a positive effect on the creative thinking skills of public high school students in West Lombok Regency. These results are in line with the findings of research conducted by Jayanto et al. [24] regarding the ability to think creatively with the guided discovery learning model which shows that this learning model can stimulate students' creative thinking abilities and help students find new knowledge or concepts.

Students' creative thinking abilities are more developed through the implementation of the guided discovery model compared to the conventional model because the steps in the guided discovery learning model, such as stimulation, identifying problems, formulating hypotheses ( arrange hypothesis), data collection (data collection), data processing (data processing), verification, and drawing conclusions (generalization), make students more active in the learning process so as to enable students to be able to master indicators of creative thinking abilities. Through a series of stages of guided discovery learning activities, students are trained to improve creative thinking skills which include flexible thinking, original thinking, detailed thinking, and fluent thinking.

Sumantri and Permana [25] state that the guided discovery learning model is one of the right choices to use in chemistry learning because it has a student-centered learning process so that students are more active in learning activities. The guided discovery learning model provides a vehicle for interaction between students that can make students accustomed to expressing their opinions. The process of processing information by students itself makes learning more meaningful and absorbed into students' long-term memory.

The guided discovery learning model is proven to be able to increase the active role of students in the learning process so that it affects better learning outcomes than students taught with conventional learning models. In accordance with the previous explanation, the guided discovery learning model can increase student activity in the learning process and participate actively through more detailed learning stages. The clear learning stages provide opportunities for students to develop their thinking skills and understanding of concepts maximally so that the learning outcomes they get are also maximized.

Learning in the experimental class from start to finish involves students fully and intensive teacher guidance requires students to follow lessons consistently. Student involvement has a positive influence on student understanding. In the learning process students will solve a problem through discussion. Discussion activities between students and students with the teacher maximize students' thinking abilities which provide opportunities for students to learn meaningfully so that the knowledge obtained by students is not from remembering or memorizing but by finding and building concepts independently.

The ability to think creatively and learning outcomes is an inseparable outcome of education. One's creativity is the result of the ability to think. Cognitive learning outcomes as an aspect related to students' thinking abilities. The more creative a person is, their thinking ability will also increase so that student learning outcomes are also higher. This is in accordance with research conducted by Jannah [26] regarding the relationship between students' creative thinking abilities and learning outcomes which states that the higher the level of student creativity, the higher the learning outcomes obtained by students, meaning that the ability to think creatively with learning outcomes has a positive relationship each other. These results are in line with research conducted by Cintia et al. [27] on the application of discovery learning models to improve creative thinking skills and student learning outcomes.

## IV. CONCLUSION

Research on the optimization of the achievement of chemistry learning outcomes through the implementation of discovery learning-based learning strategies was carried out in public high schools in Mataram and public high schools in West Lombok regency. Based on the results of the study, it was concluded that there was an effect of discovery learning on critical thinking skills, creative thinking skills, and chemistry learning outcomes of high school students.

Based on the experiences and findings of this research, the following suggestions can be made: (1) Chemistry teachers can consider the application of discovery learning models as an alternative learning strategy to improve higher-order thinking skills and simultaneously improve chemistry learning outcomes; (2) The next researcher can conduct further research by applying the guided discovery learning model to other subject matter by paying attention to other factors that can optimize student learning outcomes.

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