Modifying a discovery learning model with an aptitude-treatment interaction strategy for teaching senior high school mathematics

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Abstract. This study aims to describe the presence or absence of the effect of the Aptitude-treatment Interaction (ATI) strategy in discovery learning models on the ability to understand mathematical concepts and self-confidence. Which one is superior to the ATI strategy in the discovery learning model and the discovery learning model in terms of the ability to understand mathematical concepts and students’ self-confidence. This type of research was a quasi-experimental research with non-equivalent pretest-posttest control group design. The population was all students of class X at a senior high school in East Sumba district. Two classes as samples were chosen randomly. Descriptive statistical data analysis was carried out, then it continued with testing hypotheses using the Manova test. The results showed that there was an effect of the ATI strategy in the discovery learning model on the ability to understand mathematical concepts and students’ self-confidence. Learning with the ATI strategy in the discovery learning model is superior to learning with the unmodified discovery learning models on the ability to understand mathematical concepts and students’ self-confidence.

1. Introduction
The Curriculum 2013 is a curriculum that ready to be implemented by teachers throughout Indonesia. Many factors determine the success of achieving national education goals [1, 2]. One of them is the role of the teacher [3, 4]. The quality of education perceived by students depends on what is done by the teacher in learning activities in their class [5]. The teacher is expected to apply a good learning model. Therefore, the teacher must be able to choose the right learning model in accordance with the concepts of the subjects presented. The selection of learning models will be used in learning must be accompanied with a consideration to get good or advantages from the learning models chosen. Based the Regulation No. 65 in 2013 by Minister of Education and Culture about Standard Processes, discovery learning is one of the learning models which in accordance with the 2013 curriculum.

There are three distinctive features of the discovery learning model described by Bicknell-Holmes and Hoffman [6], namely: 1) students play an active role in creating, integrating, and generalizing knowledge through exploration and problem solving, 2) students are encouraged to learn at their own pace, and 3) the principle of using existing knowledge as a basis for building new knowledge. Similar to that, Snelbecker [7] stated that the discovery learning model requires that students participate actively and play a major role in deciding what, how, and when something must be learned. Students are expected to look for examples and use them to find principles and concepts that must be learned. The teacher has
the role to encourage students to gain experience by conducting activities that enable them to find concepts and principles for themselves in learning activities.

According to Bell [8], some of the objectives of the discovery learning model are: 1) students have the opportunity to be actively involved in learning, 2) students learn to find patterns in real and abstract conditions, 3) students also learn to form appropriate question and answer strategies and use question and answer to obtain useful information in finding, 4) students form effective ways of working together, share information, and listen and use other student's ideas, 5) there are some facts that show that skills, concepts and principles learned through discovery are more meaningful, 6) skills learned in some cases, easier to use for other activities and applied in new learning situations. Therefore, the discovery learning model is well used in the learning process.

There are four main benefits of the discovery learning model for students, namely: 1) general intellectual potential can be improved, 2) motivation is increased through shifts from extrinsic gifts (which may follow from learning) to intrinsic rewards (e.g. interest in the activity itself), 3) improvement of the memory process because it is more likely to make the material learned easier to extract and reconstruct, and 4) the acquisition of discovery heuristics [9].

Appendix IV of the Minister of Education and Culture Regulation No. 81A in 2013 about the Implementation of the General Guidelines for Learning Curriculum states that learning strategies are indispensable in supporting the realization of all competencies contained in the 2013 Curriculum. Therefore, a learning strategy which can be combined with discovery learning models is needed so the lack of discovery learning models can be minimized. Khanal [10] argued that the learning process will not be directed without a clear strategy, so that learning cannot take place effectively and efficiently. Thus, the teacher is also expected to understand the learning strategies in implementing the learning activity. For certain conditions, for example in East Sumba Senior High Schools, the suitability of the learning strategy with the target greatly influence the selection of learning strategies.

Zakaria et al [11] stated that students can gain success in mathematics learning if students are given the opportunity to communicate, reason, and develop self-confidence in solving mathematical problems. Therefore, one way that can be done is to do cooperative learning, because students learn in small groups to achieve the same goals by using their social skills. Modritscher [12] argued that the Aptitude-Treatment Interaction (ATI) learning strategy is one of the learning strategies that provide different treatment to students who have different abilities. So that the ATI learning strategy aims to create and develop a learning that pays attention to the inter-relationship between a person's aptitude and learning experience or typically with the treatment method. Students will be divided into three groups consist of groups of student who have the highest, medium and low capability; each group is given suitable or appropriate treatment based on its characteristics.

A successful of the ATI learning strategy can be seen to what extent there is a match between treatments that have been implemented in learning with the aptitude of students. The suitability will be seen in the learning achievements achieved by students. So, one of learning strategies that emphasize grouping and individual differences (ability and aptitude) in students is the ATI strategy. The higher optimization can occur in student learning achievement, which is the highest success of developing ATI strategies in learning [13].

Susanto [14] stated that mathematic is one of the subjects that can improve the ability of students to think correctly and express their opinions, so students can apply it in solving everyday problems. The mission of mathematics learning which was formulated by the National Council of Teacher of Mathematic [15], such as understanding mathematical problems is an essential mathematical thinking ability and it is a part of standard process. Lambertus [16] also argued that understanding mathematics is the basis for thinking in solving mathematical problems and problems in everyday life. According to Jbeili [17], conceptual understanding refers to the ability of students to connect new mathematical ideas with known ideas, to represent mathematics in different ways, and to determine the similarities / differences between these representations. So that, students who have good mathematical understanding skills are able to understand mathematical concepts. This is in accordance with the opinion of Asabe [18] that understanding and reasoning can improve student learning achievement.
One predictor of a person's success in his career is academic achievement in the field of mathematics [19]. Therefore, an ability to understanding the concept is very important thing that must be owned by students in mathematics learning because students can master a number of material and apply it in solving everyday problems, so that students' mathematics learning achievements will increase. One way to get students involved in learning concepts and connecting important ideas is to do mathematical discussions [20]. Students will communicate mathematically by making guesses, presenting explanations, compiling arguments, etc. in discussions. Students' thinking and reasoning will be formed through this discussion.

The indicators of understanding concept according to Kilpatrick and Findell [21] are: 1) the ability to restate the concepts that have been learned, 2) ability to clarify objects based on whether or not the requirements that form the concept are met, 3) ability to apply the concept algorithmically, 4) ability to provide examples of concepts learned, 5) ability to present concepts in the form of mathematical representations, 6) ability to associate various concepts (internal and external mathematics). The indicators were used in this study.

Yates [22] stated that self-confidence is very important for students to succeed in learning mathematics. Students will be more motivated by their self-confidence, and prefer to learn mathematics, so the end it is expected that the mathematics learning achievement achieved become more optimal. According to Lauster [23], self-confidence is an attitude or belief in one's abilities, so in his actions he is not too anxious, feels free to do things according to his desires and responsibilities, polite in interacting with others, has an encouragement of achievement and can recognize the strengths and weaknesses of yourself. Lauster illustrates that people who have self-confidence have characteristics of selflessness, do not need encouragement from others.

Al-Hebaish [24] argues that there are several important factors that influence self-confidence, namely: 1) personal experience in the form of success that will increase the development of high self-confidence, while experience failure has the opposite effect, 2) social messages received from other people, so the community, home, school and peers are important for the growth of self-confidence. Some aspects of Lauster and Guilford [25] about the characteristics and indicators of self-confidence, namely: 1) Individuals feel strong about the actions taken; 2) individuals feel accepted by the group; and 3) individuals have a calm attitude so he is calm, not easily nervous, quite tolerant of various situations.

The researcher tried to modify the ATI strategy learning steps with the discovery learning models, to obtain the following steps, namely: 1) provision of initial treatment to students using a pretest; 2) students are faced with a problem that creates confusion, so that the desire arises to investigate themselves; 3) teacher gives the opportunity for students to identify as many problems as possible that are relevant to the subject matter; 4) teacher divides students into three groups and labeled them in high, medium and low according to the classification obtained from the results of the pretest; 5) teacher distributes student activity sheet to each group of students; 6) teacher explains the material to the medium and low groups; 7) students conduct an examination to prove whether or not the hypothesis is related to the results of the discussion; 8) each group draws a conclusion by observing the results of verification and guided by the teacher and 9) teacher provides an opportunity for each student to ask questions that have not been understood in the material being studied. In addition, the teacher gives an announcement to the low group to follow the tutorial that can be held when the learning has ended. Next, the teacher gives the posttest questions as the final treatment for each group and the students do it independently.

2. Research Method
The experimental design of a quasi-experiment with nonequivalent pretest-posttest control group was used in this study. This research was conducted using one treatment (discovery learning model) which consisted of two levels, namely the ATI strategy in the discovery learning model and the discovery learning model. This study used two responses, such as the ability to understand students' mathematical concepts and self-confidence. Researchers applied pretest and posttest in the experimental group and the control group, and gave different treatment (treatment) to the experimental group. This experimental
group was given a treatment used the ATI strategy in the discovery learning model while the control group used the discovery learning model.

This research was conducted at senior high school, in East Sumba District. The population in this study were all students in grade 10 in senior high school. Two classes were selected as samples randomly; consist of one class as an experimental class and one other class as a control class. This research had been carried out in the second semester (in March-May) of the 2017/2018 academic year. The teaching material taught was in Chapter II about Composition and Inversion Function.

The instruments used in this study consisted of test and non-test instruments; test instrument in the form of a mathematical concept comprehension test ability and non-test instrument used to compare students’ self-confidence is questionnaire. The question of the ability to understand mathematical concepts was in the form of short entries and essays about the material and basic competencies that have been studied. The statements in this questionnaire were favorable and unfavorable statements. Favorable statements are positive statements that describe self-confidence. An unfavorable statement is a negative statement that describes the lack of confidence. The confidence questionnaire used is a Likert scale consisting of five response categories. The number of instruments in the self-confidence questionnaire consisted of 30 statements. This confidence questionnaire was given in the experimental class and the control class before and after being treated. The processing and analysis of descriptive statistical data did by determining the size of concentration and dissemination of data, such as the average value, maximum value, minimum value, and standard deviation.

Furthermore, the data processed and compared to determine the effect of ATI strategy in the discovery learning model on the ability to understand students’ mathematical concepts on the material that has been taught and students' self-confidence. Hypothesis testing is done by using multivariate analyze of variance (Manova) with the help of SPSS 22 program. Inferential statistical data processing and analysis were intended to analyze data by making generalizations on sample data so that the results can be applied to the population. Parametric statistical analysis is used to test hypotheses through testing population parameters, for example average (μ) and variance (σ²). The decision making criteria used in this study was if the significance value less than 0.05, then H₀ is rejected [26].

The stages of hypothesis testing with Manova were: 1) Multivariate Normality Test by using the criteria χ² from mahalanobis distance. The data said to be multivariate normally distributed if about 50% values are d_i² < χ²_0.5(p),[27]. 2) Homogeneity test in this study was carried out by Box’s M homogeneity test. The significance level chosen was α = 5%. If the significance number in the Box’s M test table was greater than the 0.05 significance level, then the conclusion that can be drawn was that the covariance matrix on the dependent variable can be considered the same. 3) The hypothesis to be tested was:

H₀₁: The ATI strategy in discovery learning models does not affect the ability to understand mathematical concepts, and the self-confidence of class X students.
H₁: The ATI strategy in discovery learning models affects the ability to understand mathematical concepts, and the self-confidence of class X students.

If there are differences between the two treatments, then the hypotheses were tested to find out which treatment is superior in terms of the ability to understand mathematical concepts, and students’ self-confidence. The hypotheses were:

H₀₂: Learning with the ATI strategy in discovery learning models is not superior to learning with discovery learning models in terms of the ability to understand mathematical concepts.
H₁₂: Learning with the ATI strategy in discovery learning models is superior to learning with discovery learning models in terms of the ability to understand mathematical concepts.
H₀₃: Learning with the ATI strategy in discovery learning models is not superior to learning with discovery learning models in terms of the ability to self-confidence.
H₁₃: Learning with the ATI strategy in discovery learning models is superior to learning with discovery learning models in terms of the ability to self-confidence.
3. Results and Discussion
This study aimed to describe the effect of ATI strategy in discovery learning models on the student’s ability to understand mathematical concepts, and self-confidence. Data on students' ability to comprehend mathematical concepts and self-confidence described in this study consisted of data before treatment (pretest) and after treatment (posttest). Experimental class was given ATI strategy treatment in discovery learning models amounted to 35 students. Whereas the control class which was given a discovery learning model amounted to 33 students. So that the total number of students as a sample is 68 students.

The results of the data description of the ability to understand mathematical concepts for the experimental class and the control class can be seen in Table 1 as follows.

| Description                      | Experiment Class | Control Class | |
|---------------------------------|-----------------|---------------|---|
| Average value                   | 52.37           | 59.48         |   |
| Standard deviation              | 12.99           | 14.50         |   |
| Maximum value                   | 75.00           | 83.00         |   |
| Minimum value                   | 34.00           | 38.00         |   |

Table 1 shows that the posttest ability to comprehend the mathematical concepts of the learning experiment class with ATI strategy in discovery learning models is higher than learning with discovery learning models. Meanings that learning with ATI strategy in discovery learning models is superior to learning with discovery learning models in terms of the ability to understand mathematical concepts.

While the results of the data description of students' self-confidence in the experimental class and the control class can be seen in Table 2 below.

| Description | Experiment Class | Control Class |
|-------------|-----------------|---------------|
| Average value | 96.49          | 105.79        |
| Standard deviation | 10.29          | 17.05         |
| Maximum value | 122.00         | 131.00        |
| Minimum value | 82.00          | 65.00         |

Table 2 shows that the final self-confidence of the experimental class students who are given learning with ATI strategy in the discovery learning model is higher than learning with discovery learning models. Meanings learning with ATI strategy in discovery learning models is superior to learning with discovery learning models in terms of students' self-confidence in all students in grade 10 in senior high school students. The maximum value and minimum value in Table 1 and 2 are the maximum values and minimum values that students had obtained when the tests were carried out in each experimental and control class.

Based on the results of the multivariate normality and homogeneity test, it is known that the multivariate assumption test has been fulfilled. Furthermore, an analysis of the data after the treatment will be carried out, namely the Manova test. Manova test is used to examine differences in the final condition of students in terms of posttest ability to understand mathematical concepts, and students' self-confidence with the help of SPSS 22 program. Manova test results after posttest treatment the ability to understand mathematical concepts, and students' self-confidence can be seen in Table 3.
Table 3. Results of Manova test after treatment

| Effect             | Value | F    | Sig |
|--------------------|-------|------|-----|
| Pillai’s Trace     | 0.097 | 3.486| 0.036|
| Wilks’ Lambda      | 0.903 | 3.486| 0.036|
| Hotelling’s Trace  | 0.107 | 3.486| 0.036|
| Roy’s Largest Root | 0.107 | 3.486| 0.036|

On the results of multivariate calculations, obtained values of Pillai’s Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root produce a significance number smaller than 0.05. In this study, the analysis used was based on the sig value of Hotelling’s Trace. Manova test results show that the sig Hotelling’s Trace value is 0.036 and the F value is 3.486. So it can be interpreted that in general there are differences in the ability of the final or posttest students in the experimental class with the ATI strategy in discovery learning models and discovery learning models in terms of the ability to understand mathematical concepts and students' self-confidence. Thus, the strategy aptitude-treatment interaction in discovery learning model affect the ability of understanding mathematical concepts, and self-confidence of class X, Senior High School in East Sumba district.

After it was known that there are differences between the two treatments, then the hypotheses were tested to find out which treatment is superior in terms of the ability to understand mathematical concepts, and students' self-confidence. Calculations were performed using independent t test as shown in Table 4.

Table 4. The results of the independent t-test

| Variable                        | Class       | N  | Mean   | T     | t_{(0.05,66)} | Decision          |
|---------------------------------|-------------|----|--------|-------|---------------|-------------------|
| The ability to understand       | Experimental| 35 | 67.486 | 2.422 | 1.980         | H_{01} rejected    |
| mathematical concepts           | Control     | 33 | 59.485 |       |               | H_{a1} accepted   |
| Self-confidence                 | Experimental| 35 | 115.457| 2.401 | 1.980         | H_{02} rejected    |
|                                 | Control     | 33 | 105.788|       |               | H_{a2} accepted   |

Explanation:

N: Number of students in each experimental and control class

The results of the statistical analysis showed that the calculated t value was greater than t table value that is 2.422 > 1.980, so H_{02} was rejected and H_{a2} was accepted. This shows that learning with the aptitude-treatment interaction strategy in discovery learning models is superior to learning with discovery learning models in terms of the ability to understand mathematical concepts. It is likely caused by the grouping of characteristics of students according to ability in participating in learning, especially with the ATI strategy is very supportive of students to earn a high understanding of mathematical concepts. Students in the treatment group ATI's strategy in discovery learning model can largely explain mathematical concepts in a structured and detailed. Students provide explanations for coherent reasons, making it easier for readers to understand the answers with students’ ability to understand concepts. Students also write mathematical symbols correctly and well, so student results are not just the result of mathematical calculations, because mathematics is not just a matter of counting. This is in accordance with the results of research from Saputri [28], that the Aptitude-treatment Interaction (ATI) learning strategy was more effective in terms of understanding mathematical concepts in class VII students of the middle high school, Bandar Lampung in the even semester of the academic year 2012/2013.

The results of the statistical analysis also showed that the calculated t value was greater than t table value that is 2.401 > 1.980, so H_{03} was rejected and H_{a3} was accepted. The value of testing also gives...
the impression that the ATI strategy treatment in the discovery learning model is superior compared to the treatment of discovery learning models in mathematics learning in terms of self-confidence. During the discussion the researcher also provided opportunities for students to further hone their confidence during group presentations. In this stage the group representatives present the results of the discussion in front of the class. While other groups were asked to provide responses, corrections, input, or questions. So that students will be motivated to be able to understand the concept and their self-confidence will be honed because they are accustomed to expressing opinions to others. This is as expressed by Maslow in Minderop [29] arguing that self-confidence can arise if needs are respected and valued are met. This will grow strength, ability, motivation and useful feelings. If this need is not fulfilled, it will create feelings of inferiority, inferiority, helplessness, laziness and despair.

4. Conclusions and Suggestions

Based on the results of data analysis and discussion, it can be concluded that there is an effect of aptitude-treatment interaction (ATI) strategy in discovery learning models on the ability to understand mathematical concepts, and students' self-confidence. Learning with aptitude-treatment interaction strategy in discovery learning models is superior to learning with discovery learning models in terms of the ability to understand mathematical concepts and students' self-confidence.

A suggestion that can be considered by math teachers to improve their ability by understand mathematical concepts, and students' self-confidence so that the ATI strategy in discovery learning models can be applied in the learning process of mathematics. Thus, the goal of learning mathematics can be achieved optimally.

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