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The effect of discovery learning on students’ integrated thinking abilities and creative attitudes

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Abstract. The aims of this study was to investigate the effect of discovery learning model on students’ integrated thinking abilities in the form of analytical thinking skills and science process skills, and students’ creative attitudes in the buffer solution lesson. The population was students of eleventh grade students of science class in Yogyakarta, academic year of 2017/2018. The sample of this study consisted of two classes in Yogyakarta public high school taken using a random sampling technique. Each experimental and control class was 32 students. The treatments for experimental class was the use of discovery learning, and expository model for the treatment on control class. Data collection used in this study was an integrated thinking ability test and students’ creative attitudes questionnaire. The data of students’ integrated abilities and creative attitudes were analyzed by observing the results of significance value and partial eta squared on MANOVA test. The results of multivariate analysis showed that there was an effect of discovery learning on students’ integrated thinking abilities and creative attitudes of 12%. This means the integrated thinking abilities and creative attitude of students applying discovery model is better than integrated thinking abilities and creative attitudes of students with expository model.

1. Introduction
The chemistry learning process cannot be separated from cognitive development and students’ skills development. This is due to the relationship between cognitive and process skills. Process skills are essential in understanding and applying chemical concepts [1]. Process skills are very important in learning process to acquire a knowledge [2]. Actamis and Ergin [3] are revealed that science process skills are skills that can be used by students in everyday life in order to improve students’ understanding and essence of science. Science process skills also emphasize students’ ability to find their own knowledge based on learning experiences, laws, principles and generalizations, so it can provide students more opportunities to enhance their thinking skills [4]. Also clarified that science process skills are considered to have a correlation with higher thinking skills.

Higher thinking skills in Bloom cognitive domain is at the analytical, evaluation and creating level [5]. Other perspectives defined high-level thinking skills as thinking abilities that not only require the ability to memorize or know, but also require other higher abilities such as the ability to think critically and creatively and to solve a problem [6]. Through creative learning, students are expected to be able to process abstract and complex chemical information into new and original knowledge [7]. Analytical thinking ability is the ability of students in visualizing, articulating and solving complex problems to make logical decisions based on information obtained [8]. Analytical thinking is part of high-level thinking that includes the ability to hone and apply information that can provide knowledge [9].
Analytical thinking in Bloom's taxonomy revision is part of the C4 cognitive domain which consists of distinguishing, organizing, deducing, and attributing [10]. Irwanto et al. [11] described that process skills students relate with thinking activity and require reasoning. Science process skills is a tool to generate and use scientific information on scientific research to solve problems, and the students are able to get these skills through science learning activities [2]. Science process skills are not only used in the process of science learning, but also needed in solving every problem in the 21st century. Mansila and Jackson [12] argued that there are four global competences of dimension skills that the students need to have in order to acquire the process skills, namely investigate the world, recognize prespective, communicating idea, and taking action. Further, Mansila and Jackson [12] explained that the global competences can enhance students' thinking skills including critical thinking, high-level thinking and analytical thinking

Creativity is the affective aspect of learning outcomes (attitudes) as a result of creative thinking in order to understand a thing or the ability to process information. Kenneth [13] revealed effective instructional strategies that creative thinking is thought of putting information together to come up with a whole understanding, concept, or idea. The four stages generally identified with the development of creative thought are preparation, incubation, illumination, and verification. Numerous thinking are used during each of these stage of the creative process. In fact, the greater the flexibility in thinking, the greater the possibility for developing student's creative thinking ability. Dessailly [14] identified key elements of creativity, namely (1) generating new ideas, (2) applying the known skills and ideas in different contexts, (3) taking other people's ideas or starting points and moving them on or personalizing them, (4) communicating ideas in interesting or varied ways, (5) putting different or disparate ideas together to make something new, (6) working towards a goal or set of goals, (7) evaluating their own or others' work, and (8) adapting and improving on their work in the light of their own or others' evaluations. This study used six aspects of creativity, namely curiosity, feeling the challenge, imaginative, original thinking, detailed thinking and willingness to take risks.

One of the solutions to improve students' science process skill, analytical thinking skill and creativity is the selection of appropriate learning models, such as using discovery learning models. Discovery learning is thought to increase the ability of students to transfer information, they construct to other areas, as it allows the students to independently explore broader issues [15]. Discovery is the mental process of understanding the concepts and principles, and is a study of how to use the mind to find. With discovery learning, the students construct knowledge based on new information and data collected by them in exploratory learning environment [16]. Learning discovery, making children can learn too think analysis and try to solve their own problem encountered. Discovery learning consists of six syntax, namely stimulation, problem statement, data collection, data processing, verification and generalization [17]. The main targets of discovery learning models are maximum students engagement in teaching and learning activities and develop self-belief about what is found during the learning process.

The purpose of this study was to determine the effect of discovery learning model on students' integrated ability and students' creative attitude. As for benefit of this study, it is expected that it can improve integrated thinking ability and creative attitudes of students on eleventh grade chemistry subject, as one input for educator to improve integrated thinking ability and creative attitudes in yogyakarta high school, can be applied in learning and learning increase knowledge and ability to realize

2. Methods
This research is a quasi-experimental research with post-test only control group design as presented in Table 1. The population of this research is eleventh grade of science students of high schools in Yogyakarta, academic year of 2017/2018. The research sample consists of two classes selected by random sampling. Learning in experimental class used discovery learning models while learning in control class used expository learning models. Student worksheets are used to assist the learning process. Student worksheets based on discovery learning model are used in the experimental class, and students worksheet are based on expository learning model in control class.
Table 1. Research design

<table>
<thead>
<tr>
<th>Class</th>
<th>Treatment</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experiment</td>
<td>X</td>
<td>Z, A</td>
</tr>
<tr>
<td>Control</td>
<td>Y</td>
<td>Z, A</td>
</tr>
</tbody>
</table>

Note:
X = Discovery learning model
Y = Expository learning model
Z = Result of integrated thinking abilities
A = Students’ creative attitudes questionnaire

The study used an integrated thinking ability test developed by Sukmasari [18] with the Aiken index value is 0.87 and reliable if the instrument was tested to the participants with the ability (θ) between -3.70 to 2.95. of the twelve integrated thinking ability test items developed by Sukmasari, five items were selected to be used in this study. While for the data of creative attitudes students were collected using a questionnaire consisting of 27 item and covered aspects of curiosity, feeling challenges, imaginative, detailed thinking and willingness to take risk. Data of students’ creative attitude questionnaire were ordinal data which have no absolute value on an object, so it must be converted to interval data. The data analysis technique used was Multivariate Analysis of Variance (MANOVA) at a significance level of 0.05. Before analyzing the data, there are several prerequisites that must be carried out in conducting MANOVA test. They include two variables, two independent groups, no interclass correlations, having minimum sample size, no multicollinearity, a linear relationship, multivariate normality, multivariate outlier test, and homoscedasticity test [19]. Of the nine tests above, the researchers particularly considered normality and homogeneity test in this study. The researchers measured multivariate normality through Mahalanobis vs chi-squared test. The homogenity test of variance was carried out through Box’s test of equality of covariance matrices. Besides, Hotelling’s Trace test was used for multivariate analysis and partial eta squared test in order to see the effect of discovery learning models on students’ integrated thinking abilities and creative attitudes.

3. Result and discussion

Data of the research were the results of integrated ability test and students’ creativity questionnaire. Multivariate normality test using Mahalanobis vs chi-squared test. The results show that Mahalanobis value which is under the chi-square value from the experimental class is 15 out of 32 students with a percentage of 46.88%. Similarly, students from control class who had a smaller Mahalanobis value than chi square were 19 out of 32 students (53.13%). Based on the percentage of Mahalanobis and chi-square values in both samples, the results indicated that the distribution of data in each class meets the requirements of multivariate normality. The significance value obtained from Box’s M test was 0.807, meaning that the significance value of Box’s M test is greater than 0.05, thus it can be concluded that the samples were from homogeneous population. The summary of the result Box’s test of equality of covariance matrices is presented in table 2. After testing multivariate normality and variances of matrix homogeneity test, MANOVA test (difference testing) was measured as the further test.

Table 2. Result Box’s test of equality of covariance matrices

<table>
<thead>
<tr>
<th>Box’s M</th>
<th>F</th>
<th>df1</th>
<th>df2</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,010</td>
<td>0.325</td>
<td>3</td>
<td>691920,000</td>
<td>0.807</td>
</tr>
</tbody>
</table>

To find out whether there are differences in students’ integrated thinking abilities and students’ creative attitude in the experimental class and control class, a multivariate test was conducted using Hotelling’s Trace test. Hotelling’s Trace test was selected based on the results of the prerequisite MANOVA test, in which the data was normally distributed and had a homogeneous variant matrix. Significance value obtained from multivariate test for the two dependent variables was 0.02 which was smaller than 0.05. This indicated that there are differences in integrated thinking abilities and creative
attitude between students who learn with discovery learning model and students who study with expository learning model. Therefore, the effect of discovery learning model on students’ integrated ability and students’ creative attitude was 12%. Result of multivariate test and partial eta square value is presented in Table 3.

<table>
<thead>
<tr>
<th>Effect</th>
<th>Value</th>
<th>Hypothesis df</th>
<th>Sig.</th>
<th>Partial eta squared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hotelling’s Trace</td>
<td>0.136</td>
<td>2.000</td>
<td>0.020</td>
<td>0.120</td>
</tr>
</tbody>
</table>

The results of this study indicated that discovery learning models not only influence the integrated abilities, but also influence both students’ integrated ability and students’ creative attitude at once. This is because discovery learning models emphasize the importance of structures or ideas towards a discipline, namely through active students’ involvement in the learning process. Through the syntax of discovery learning models, students were guided by the teacher to find the concepts and principles presented by the teacher that was not fully comprehensive. Catronova [20] stated that “in discovery learning, students are active. Learning is not defined as simply absorbing what is said or read, but actively seeking new knowledge. Students are at least engaged in hands-on purpose for finding answer and learning more”. Jamil [21] added that in discovery learning students are encouraged to actively learn, through their own active involvement to concepts and principles, and teachers encouraged students to have experience and conduct an experiment that enables students to discover principles and concepts for themselves. With the discovery of principles and concepts by students, students may not be easy to forget, because the understanding of principles and concepts has been recorded in the long-term memory of the students. In addition, discovery learning model can improve students’ reasoning, the ability to think freely, and train students’ cognitive skills to find and solve problems without the help of others [22]. Kutsiyah [23] argued that discovery learning models have a significant effect on learning. Using module based on discovery learning in the learning process is effective to increase generic science skill [24]. Hence, the significant difference in this research is the discovery learning model with the help of students’ creative attitudes.

4. Conclusion
Based on the results of the research and discussion, it can be concluded that discovery learning model affects 12% to students’ integrated abilities and creativities. This means the integrated thinking abilities and creative attitude of students applying discovery model is better than integrated thinking abilities and creative attitude of students with expository model.

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