The analysis of implementation of discovery learning to improve student’s creative thinking skill in local super antimagic total face coloring problem

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Abstract: Creative thinking skill is essential in the era of 21st century, since everyone must have 4C’s skills. 4C’s skills consists of creative and innovative skills, critical thinking skills, communication, and collaboration. However, in learning process, students do not show the optimal creative thinking skill level. Therefore, in this research, Discovery Learning-based research was implemented to improve students’ creative thinking skill. The research method used in this research was the combination of qualitative and quantitative methods or what so called as combined method. This research involved 86 students which were divided into two classes; 44 students in the experimental class and 42 students in the control class. The result of this research obtained through post-test and pre-test. Prior to research activities, we tested the homogeneity of the two classes by using a pretest result. The result shows sig score is 0.913 > 0.05, thus the differences of mean of two classes is not significant. It implies the two classes are homogeneous. Furthermore, we also tested the normality, and finally we have the postest data analysis. The results showed that there was a significant different from the value of independent t-test toward post-test sig. (2-tailed) 0.000, because 0.000 < 0.05 then H0 was rejected, therefore there was an average difference between post-test value of control class and experimental class. While the students creative thinking skills indicates that 39% is categorised as very high level of creative thinking, 43% is categorised as creative thinking, 16% is categorised as fair level of creative thinking and 2% is categorised as low level of creative thinking. Thus, it can be concluded that discovery learning model could improve students’ creative thinking skill.

1. Introduction
Education refers to a tool to determine the quality of society in adapting the progress of science and technology which is developing very rapidly in 21st century era, therefore the education is being developed to improve the quality of education. The skill to think creatively plays an important role in 21st century era, as everyone in this era is required to possess 4C’s skills, namely critical thinking, communication, collaboration, and creativity.
Creative thinking skill is an alternative way of solving a problem as it is able to improve the quality and effectiveness of problem solving and the results of decision making made [1]. In a learning process, students should be encouraged to develop their thinking skills. In mathematics field, creativity is often associated with solving and submitting problems. According to [12], creativity reflects the ability to create more. The ability to create more can be interpreted as divergent thinking or thinking with many answers to one problem. This is supported by [8], who said that creativity is not a single identity owned or not owned by people, but is a combination of many specific thought processes, characteristics, and behaviors. So it can be concluded that creativity is a process of thinking, characteristics, and behavior of seeking many answers to a problem.

[2] points out that creative thinking is a thinking skill, including a skill as individual freedom to realize his imagination, provide the opportunities to think and express their ideas to obtain new information. The creative thinking process developed by [15] is one of the most commonly used theories to find out the creative thinking process covering four stages, which were the preparation, incubation, illumination, and verification stages.

According to [6], creativity is affected by four aspects consisting personal, motivator, process, and product or better known as 4P in creativity. Hence, creativity is not merely about the products or results, but also about the motivation of a creative person to be involved in the process of creative thinking to produce creative products. Personal aspect is categorized into four aspects, which were the aspects of fluency, flexibility, originality, and elaboration [3].

In this research, what is meant by the skill to think creatively is the skill to think creatively. Students in proving lemma or theorems, in this research, indicators to determine the students’ creative thinking skills were only assessed through 3 aspects: fluency, flexibility, and novelty (originality). Whereas the elaboration aspect was not used as it was not capable to provide valid information to measure creative thinking skills. The first indicator of creative thinking ability is (1) Fluency, the success of this indicator covers two sub indicators that are (a) The students were able to determine total face coloring, (b) the student are able to generalize the number of total face coloring, the second indicator is (2) Flexibility, the success of this indicator covers three sub indicators that are (a) The students are able to give notes on graph, (b) The students were able to determine their cardinality, (c) developing the bijection function, the third indicator is (3) Novelty (Originality), the success of this indicator covers two sub indicators that are (a) The students are able to make a new graph that had not been studied yet on the concept of total face coloring, (b) The students are able to create the original ideas as the results of their thoughts. Except the characteristics of creative thinking as stated before, another thing to know is someone’s level in the process of thinking creatively. According to Siswono, a gap is made on someone’s level of creative thinking. The intended level is according to the work produced by the Student [11].

But, learning still does not maximize the students’ creative thinking skills. Therefore, Discovery research based learning would be implemented in this research in order to improve the skill to think creatively in proving lemma or theorem on the material of Local Super Antimagic Total Face Coloring. Discovery Learning is defined as a teaching model regulating the learning process so that the students obtain the knowledge they do not know yet; it was not through the announcement, they found it themselves partially or entirely. Discovery learning model is a learning model developed based on the view of constructivism. According to [5], discovery learning is a learning process occurred when learning material is not presented in its final form, but the students are expected to organize it themselves. Discovery Learning gives the students the opportunity to be actively involved in teaching and learning process [9]. Discovery models are able to provide the opportunities for students to be more active in the learning process, besides that the application of discovery learning could improve students’ creative thinking skills.
The material used was Local Super Antimagic Total Face Coloring, which was regional coloring. Regional coloring is coloring each region in the graph so that there would be no adjacent region that had the same color. The implementation of regional coloring could be found in map coloring. In map coloring, different colors were given from each side of the area. Super Antimagic Local Total Face Coloring was one of the materials in discrete mathematics.

2. Research Methods

The method of this research was a combination of research methods (Mixed Methods). Combined research is a research that combines two types of research; in which they were qualitative and quantitative researches. The design used was sequential explained the findings from quantitative data (e.g., after assessing pragmatic competence at group-level, following up on several participants to gain understanding about their characteristics) [7] and [13] also applied this model to their research.

The procedures of this research covered three stages with research design, qualitative research to find out the level of students’ creative thinking, quantitative research to determine the effect of Discovery Learning in improving creative thinking skills on Local Super Antimagic Total Face Coloring, and qualitative research to find out the interview results of creative thinking skills on Local Super Antimagic Total Face Coloring. This research was done to 86 students consisted of 42 students of the control class and 44 students of the experimental class. In the control class, usual learning was done and in the experimental class discovery learning model was implemented. The results of this research were in the form of test and observation.

To measure the level of the students’ creative thinking skill, a measurement tool which is appropriate with the measured indicator is needed. The researcher set a new and different test instruments. The test instruments used in this research was discussing the coloring of total face on ladder graph consisted of labeling points, labeling sides, and labeling area. The details were explained as follow.

![Image of total face coloring labeling question](image)

**Figure 1.** The example of total face coloring labeling question

From the obtained graph, the first step was labeling points, sides, and face. After that, sum up points, sides, and face so each area which has same sides has different color. The aim of this task was to make the students understand about the labeling points, sides, and face so every area which has the same sides has different color.

The instruments of this research were test, observation, and interview. The procedures of the research were as follow:
The initial step of the research had been done by using qualitative method to 88 students in order to know their creative thinking level. We conducted reliability and validity tests for the instrument of post-test before looked at the result of our research. After conducting test for the instrument, 88 students were tested by using pre-test.

3. Results
The following was the result of validity and reliability tests that we had done beforehand.

**Table 1.** The result of questions’ validity

| Correlations | No. 1 | No. 2 | No. 3 | No. 4 | Total |
|--------------|-------|-------|-------|-------|-------|
| Pearson Correlation | 1     | .316  | -.185 | -.074 | .525  |
Correlations

|                | No_1 | No_2 | No_3 | No_4 | Total |
|----------------|------|------|------|------|-------|
| Sig. (2-tailed)|      |      |      |      | .001  |
| N              | 34   | 34   | 34   | 34   | 34    |
| Pearson Correlation | .316 | .278 | .218 | .401 |       |
| Sig. (2-tailed) | .068 | .112 | .216 |      | .019  |
| N              | 34   | 34   | 34   | 34   | 34    |
| Pearson Correlation |    |      |      | .591 | .525  |
| N              | 34   | 34   | 34   | 34   | 34    |
| Pearson Correlation | .185 | .278 | 1    |      |       |
| Sig. (2-tailed) | .295 | .112 |      |      | .001  |
| N              | 34   | 34   | 34   | 34   | 34    |
| Pearson Correlation |    |      | .591 | 1    | .623  |
| N              | 34   | 34   | 34   | 34   | 34    |
| Pearson Correlation | .074 | .218 |      |      |       |
| Sig. (2-tailed) | .676 | .216 | .000 |      | .000  |
| N              | 34   | 34   | 34   | 34   | 34    |
| Pearson Correlation | .525 | .401 | .525 | .623 | 1     |
| Sig. (2-tailed) | .001 | .019 | .001 | .000 |       |
| N              | 34   | 34   | 34   | 34   | 34    |

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

From Table 2, it could be seen that the value of $r_{count}$ of question 1 was 0.525, question 2 was 0.401, question 3 was 0.525, and question 4 was 0.623. All questions had the value of $r_{count} > r_{table}$ with N=34, therefore all questions were valid.

Table 2. The result of questions’ reliability

| Reliability Statistics |
|------------------------|
| Cronbach’s Alpha       |
| N of Items             |
| .648                   |
| 5                      |

Based on Table 2, it could be seen that the value of reliability was 0.648 and $r_{table}$ of the significant level was 0.05 with dk= N= 34, $r_{table} = 0.339$. Therefore, $r_{count} > r_{table}$ so the instrument was said to be reliable.

After conducting the test for the instrument, 88 students were tested by using pre-test, in the control class, it was obtained that 17% students were in the category of very creative, 19% students were creative, 43% students were quite creative, and 21% students were uncreative. The results of the above analysis show that students' creative thinking skills are still lacking. Because the average student is still at the level of being quite creative.
In the experimental class, it was obtained that 16% students were in the category of very creative, 16% students were creative, 39% students were quite creative, and 30% students were uncreative. The results of the above analysis show that students’ creative thinking skills are still lacking. Because the average student is still at the level of being quite creative and less creative.

After conducting pre-test for both classes, the learning was held in those classes as well, the control class used usual learning, while the experimental class used discovery learning model. The results of post-test were analyzed and the results were presented as follow. The percentage of students’ creative thinking ability in the control class obtained that 5% students were in the category of very creative, 19% students were creative, 50% students were quite creative, and 26% students were less creative. The results of the above analysis show that students’ creative thinking skills are still lacking. Because the average student is still at the level of being quite creative and less creative.
In the experimental class in which discovery learning was implemented, it was obtained that 39% students were in the category of very creative, 43% students were creative, 16% students were quite creative, and 2% students were less creative. The results of the above analysis indicate that students’ creative thinking skills are in the creative category. Because on average students are still at the level of creative and very creative.

The figure above showed that there was an improvement of the average score of the experimental class after the implementation of discovery learning. The next step was analyzing the data obtained from the pre-test and post-test by using SPSS. Data analysis done was quantitative method. The first step in the analysis by using SPSS was homogeneity test from both classes to find out if both classes had the same skills.

| Value                      | Levene Statistic | df1 | df2 | Sig. |
|----------------------------|------------------|-----|-----|------|
| Test Homogeneity of Variances |                 |     |     |      |
| very creative              | .012             | 1   | 84  | .913 |
| creative                   |                  |     |     |      |
| quite creative             |                  |     |     |      |
| uncreative                 |                  |     |     |      |
The result of homogeneity test revealed that the significance was 0.913. Due to the significance was higher than 0.05, therefore it can be concluded that two data classes of the students’ understanding based on the achievement level had normal distribution or had the same skills.

Table 4. The Pretest of Normality Test

| CLASS               | Kolmogorov-Smirnov<sup>a</sup> | Shapiro-Wilk |
|---------------------|---------------------------------|--------------|
| CONTROL             | .120                            | .970         |
| EXPERIMENTS         | .095                            | .955         |

<sup>a</sup> This is a lower bound of the true significance.

The normality test produced the sig value as much as 0.125 in the control group and sig value as much as 0.200 in the experimental group. The results of the normality test means that both groups were normally distributed as the sig value > 0.05. Since the produced data were homogeneous and normally distributed, these data could be brought up to the next test, which was the independent sample test.

Table 5. Test of independent t-test of the pre-test

| VALUE                | Levene's Test for Equality of Variances | t-test for Equality of Means |
|----------------------|----------------------------------------|------------------------------|
| Equal variances      | F                                        | t                  |
| Equal variances      | Sig.                                    | df                |
| assumed              | .012                                    | .542               |
| not assumed          | .913                                    | 84                 |
|                      |                                        | 83.913             |
| Sig. (2-tailed)      |                                        | .589               |
| Mean Difference      | .636                                    | 1.174              |
| Std. Error Difference|                                        | 1.174              |
| 95% Confidence Interval of the Difference | Lower | .1.698           |
|                      | Upper                                   | 2.971              |
|                      |                                        | 2.970              |

Based on the result of the test found that the significance value of t count was 0.589 therefore from the data it can be concluded that 0.589 was higher than 0.05 so that H<sub>0</sub> accepted, it means the mean score of the pre-test result from both classes was similar or not so much different.

After conducting the pre-test in the control and experimental classes, therefore the learning process was conducted in the experimental class by using discovery learning model and the control class was taught by using the common learning, after that the data obtained were tested in SPSS, the first test was homogeneity test.
The result of homogeneity test done obtained the sig value of 0.366. It can be said as significant if it was higher than 0.05, therefore the variants of post test data groups of control and experimental classes were homogeneous. After conducting the homogeneity test, the normality test then was done. This test conducted to know whether the data collected had normal distribution or not. The data can be said as normal if the significance value was higher or equal to 0.05.

Based on the result of the test found that the significance value in the experimental class was 0.200 and in the control class was 0.091, because the significance values in both classes were higher than 0.05, therefore the data from both classes had normal distribution. Then, the last was independent t-test test.

The result of independent t-test obtained the result in the control class was 0.000 and in the experimental class was 0.000, because the test results from both classes showed it was less than 0.05 therefore H0 was rejected, there was mean difference between pre-test and post-test in the
experimental and control classes. Based on the result of analysis data by using inferential statistics of SPSS, in the implementation of pre-test it was known that there was no mean difference between the control and experimental classes. Therefore, the students in both classes had relative skills. Then, the learning process was conducted in both classes, the experimental class was taught by using discovery learning and the control class was taught by using common learning. The result of data analysis from the implementation of the post-test known that there was mean difference score between two classes. This showed that the learning by using discovery learning model gave greater changes than common learning. So, discovery learning model could improve the students’ creative skills.

The first work shows how students sign the symbol to in the graph, students to determine total face coloring, and students to generalize the number of total face coloring, while that these students cannot determine the cardinality of the graph.

$$\text{Figure 7. The result of subject 1 work on less creative}$$

To know deeply the student activities of their creative thinking process, we use a potrait phase. The portrait phase is taken to draw graphics of their creative thinking processes under the implementation of discovery learning based learning. By interviewing students S1, we can explore their thoughts from the first step, following the steps and final steps students have taken. We draw directional lines to move from the previous step to the next step. We can finally describe the graphical representation of their creative thinking process in the following portrait phase, see Figure 8 Figure 7 shows the process of creative thinking of subject 1 skills in solving the problem total face coloring. In steps S1 starts from 2a, he goes back to 1a, he goes to 1b, and stopping, S1 were not able to determine their cardinality, this means S2 is only at a less creative level.

$$\text{Figure 8. Phase portrait of subject 1 work on less creative level}$$
The second work shows how students to determine total face coloring, students begin symbol to in the graph, students determine the cardinality of the graph, students to make a new graph that had not been studied yet on the concept of total face coloring, while that these students cannot to generalize the number of total face coloring.

![Figure 9. The result of subject 2 work on quite creative level](image)

To know deeply the student activities of their creative thinking process, we use a portrait phase. The portrait phase is taken to draw graphics of their creative thinking processes under the implementation of discovery learning based learning. By interviewing students S2, we can explore their thoughts from the first step, following the steps and final steps students have taken. We draw directional lines to move from the previous step to the next step. We can finally describe the graphical representation of their creative thinking process in the following portrait phase, see Figure 12 Figure 11, shows the process of creative thinking of subject 2 skills in solving the problem total face coloring. S2 starts from 1a, he goes jump to 2a, he goes to 2b, goes jump to 3a, go ahead 3b and stopping. S2 were not generalize the number of total face coloring, this means S2 is only at a quite creative level.

![Figure 10. Phase portrait of subject 2 work on quite creative level](image)

The third work shows how students begin notation to in the graph, determine the cardinality of the graph, students to determine total face coloring, generalize the number of total face coloring, and students are able to make a new graph that had not been studied yet on the concept of total face coloring, while that these students cannot developing the bijection function.
To know deeply the student activities of their creative thinking process, we use a portrait phase. The portrait phase is taken to draw graphics of their creative thinking processes under the implementation of discovery learning based learning. By interviewing students S3, we can explore their thoughts from the first step, following the steps and final steps students have taken. We draw directional lines to move from the previous step to the next step. We can finally describe the graphical representation of their creative thinking process in the following portrait phase, see Figure 13. Figure 12, shows the process of creative thinking of subject 2 skills in solving the problem total face coloring. S3 starts from 2a, goes to 2b, goes back to 1a, go ahead 1b, jump to 3a, go ahead 3b and stopping, S3 cannot to developing the bijection function. This means S3 is only at a creative level.

Figure 12. Phase portrait of subject 3 work on creative level

The fourth work shows how student to determine total face coloring, students can expand, student begin notation to in the graph, determine the cardinality of the graph, can determine the bijective function, and students to make a new graph on the concept of total face coloring.
Figure 13. The result of subject 4 work on very creative level

To know deeply the student activities of their creative thinking process, we use a portrait phase. The portrait phase is taken to draw graphics of their creative thinking processes under the implementation of discovery learning based learning. By interviewing students S4, we can explore their thoughts from the first step, following the steps and final steps students have taken. We draw directional lines to move from the previous step to the next step. We can finally describe the graphical representation of their creative thinking process in the following portrait phase, see Figure 13 Figure 12, shows the process of creative thinking of subject 2 skills in solving the problem total face coloring. S4 starts from 1a, go ahead 1b, 2a, 2b, 2c, 3a, and 3b.. S4 has very creative thinking than S1, S2, and S3 because S4 can developing the bijection function. That means S4 at a very creative level

Figure 14. Phase portrait of subject 4 work on very creative level
4. Discussion
According to [10] in a learning process, students should be encouraged to develop their thinking skills. In the field of mathematics, creativity is often associated with solving and submitting problems. [14] also assess the ability to creative thinking in their research. This research was conducted to analyze the ability to think creatively and the application of discovery learning. According to [4], discovery learning is a type of learning where students build their own knowledge by conducting an experiment and finding a principle from the results of the experiment. Discovery model was able to provide opportunities for students to be more active in the learning process, besides that the application of discovery learning could improve students' creative thinking skills. This research produced data, namely 17 students at a very creative level, 20 students at the creative level, 7 students at quite creative level, and 1 student was not creative.

5. Conclusion
Based on the results of the discussion above, researchers have drawn the following conclusions. First, based on the results of the test, students who had very creative, creative, quite creative, and not creative thinking skills made significant improvements between pre-tests and post-tests. All results related to the learning process are implemented, namely learning with discovery learning models. Then based on the results of interviews with the students, there were several difficulties when doing the assignments. This happens because students were not familiar with discovery learning based learning and Super Antimagic Total Face Coloring material. Second, the level of students' creative thinking skill based on their performance in the pre-test was in the category of being quite creative, and the results of the tests revealed that student work was in the creative category. Third, based on the results of analysis and discussion, factors that influence the level of students' creative thinking skills were including the accuracy of students in proving theorems and finding functions. Finally, developing students' creative thinking skills can be done by increasing their motivation in developing concepts taught by lecturers. So discovery learning models when implemented into Combinatorics, can successfully improve students' creative thinking skills. This research is only carried out on a small scope of advice for future researchers to implement it in a larger scope.

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