The analysis of research based learning implementation in improving students conjecturing skills in solving local antimagic vertex dynamic coloring

P L Wardani¹,², Dafik¹,², I M Tirta³

¹CEREBEL University of Jember
²Department of Mathematics Education, University of Jember
³Department of Mathematics and Science, University of Jember

Email : wardaniputu@yahoo.com

Abstract
This study aims to determine the application of research based learning in improving student conjecturing skills in solving local antimagic vertex dynamic coloring problems. The research method used in this study can be regarded as a combination of qualitative and quantitative methods. Qualitative methods are used to obtain data related to test results on each indicator and the results of phase portraits while quantitative methods are used to statistical analysis. Experiment and control classes each consists of 41 and 43 responden. Both classes were given different treatments. In the experimental and control class applied research based learning methods and the experiment class will use student worksheet. Result the students conjecturing skills indicates for control class that 21% is categorized as low level, 29% is categorized as fair level, 27% is categorized as high level and 23% is categorized as very high conjecturing skill and than experiment class that 13% is categorized as low level, 24% is categorized as fair level, 36% is categorized as high level and 27% is categorized as very high conjecturing skill. The results of this study of homegenity of two classes by using a pretest result show sig score 0.681 > 0.05 thus the differences of mean of two clasess is not significant. The inferential statistical result of the independant sample t-test on the posttest results showed that the sig(2-tailed) value was 0.007 (p ≤ 0.05) so that was significant. The conclusion is there is a significant impact of the application of research based learning in improving the students conjecturing skills on solving local antimagic vertex dynamic coloring.

1. Introduction
Higher education has also been reconstructed the curriculum based on the Permenristek Dikti Number 44 of 2015 concerning SNPT and Perpres Number 2 of 2010 concerning KKNI, the curriculum in higher education is called KPT 2013. The learning process in higher education has implemented the student-centered learning to be actively participated in the learning activities. According to constructivism theory, the lecturers do not only give knowledge to the students, but the students must be active to build knowledge in their memory. When the students are thinking to solve a problem, they tend to predict the solution of the problem, so that the students make a hypothesis based on the logical reason or fact but it cannot be ascertained the truth or known as conjecture. [12, 13] state that conjecture is a statement obtained from reasoning process, but the truth cannot be ascertained. While, based on [7] conjecture is a logical statement, but the truth is not ascertained by the solver so that the truth cannot be ascertained as true because it has no examples of denial. Conjecture produced from conjecturing process and its process
is based on the constructivism learning theory. In the conjecturing process, the students have active roles to produce a meaningful conjecture based on their knowledge. Conjecturing process emerges when an individual faces an unknown problem. Conjecturing process done based on the learning experience or belief own by an individual in solving the problem they face. Conjecturing process is solving strategy according to the constructivism learning theory.

Conjecturing process conducted in this research belonged to conjecturing empirical induction type from finite numbers of discrete cases. Based on [2] the experts’ opinions, it can be concluded that the steps of conjecturing are, as follows: (1) the first activity done in the conjecturing process is observing cases of the problem proposed; (2) using a strategy to organize the cases; (3) observing the continued and regular situation of the cases and imagining that the same pattern can be applied for unknown cases; (4) formulating conjecture is an activity of making a statement based on the empirical fact but with element of doubt in it; (5) the following activity is validating the conjecture that has been made but not in general; (6) generalizing the conjecture; (7) validating the generalization by giving several reasons to assure people that the conjecture made is correct. Here are the indicators of conjecturing process as follows:

**Table 1. Indicators of conjecturing**

| Indicator                         | Sub-Indicator                          |
|-----------------------------------|----------------------------------------|
| Observing the Case (LV 1)         | Drawing the graph (1a)                 |
|                                   | Naming the graph (1b)                  |
| Organizing the Case (LV 2)        | Giving label in the graph (2a)         |
|                                   | Predicting to solve the problem (2b)   |
| Finding and Predicting the Pattern (LV 4) | Digging information based on the problem (3a) |
|                                   | Declaring the vertex weight (3b)       |
| Formulating the Conjecture        | Determining the pattern of vertex weight (4a) |
|                                   | Clarifying the vertex weight (4b)      |
| Validating the Conjecture (LV 5)  | Testing (5)                            |
| Generalizing the Conjecture (LV 6) | Determining the generalization of the vertex (6) |
| Validating the Conjecture (LV 7)  | Validating the generalization of the pattern (7a) |
|                                   | Comparing (7b)                         |

One of the learning model alternatives that can be used to improve the students’ conjecturing skills is research based learning. Lockwood states that research based learning is a research based learning model to build knowledge by formulating a hypothesis, collecting data, analyzing, drawing a conclusion and compiling a report. Based on [5] RBL is the learning approach that emphasizes on learning with training, learning from the real situation, producing something from thinking process, functions systematically, forming an individual knowledge through the research process to solve a problem, emerging the answer of a doubt and analyzing data by itself. [8] explains that: "research based learning is a learning system that uses authentic-learning, problem solving, cooperative learning, contextual and the inquiry approach that is based on the philosophy of confrontivism (continuous and continuous student self-development) ".

The purpose of this research was to analyze the learning tools to improve the students’ conjecturing skills in the learning activity based on the research based learning in completing local antimagic vertex dynamic coloring problem. The data obtained from
the students’ answer sheets (LKM), post test and monograph. Student worksheet (LKM) used was LKM with conjecturing indicators in it. The chart of RBL implementation steps [4, 11] is attached to the figure 1:

**Figure 1.** Syntax research based learning

The purpose of this research was to investigate the effectiveness of research based learning in improving the students conjecturing skills on solving local antimagic vertex dynamic coloring. This concept was introduced in [1, 6]

**Definition 1.1.** Local antimagic vertex dynamic coloring we mean a graph coloring combining the definition of vertex dynamic coloring and a local antimagic labeling. Local antimagic dynamic coloring, such that:

1. $w(u) \neq w(v)$ where $\sum_{e \in E(u)} f(e)$ and
2. for each vertex $v \in V(G)$, $|w(N(v))| \geq \min\{r, d(v)\}$.

The local antimagic vertex dynamic chromatic number denoted by $\chi^{la}_{r}$ is the minimum number of colors needed to color $G$ in such away the graph $G$ to be local antimagic vertex dynamic graph. In this study, students were asked to find chromatic number of local antimagic vertex dynamic coloring on a graph based on the definition and steps of RBL.

**2. Research Methods**

The method used in this research was mixed-methods between qualitative and quantitative approaches. Quantitative data is the main information obtained from the test which has conjecturing indicators on the material of local antimagic vertex dynamic coloring then the qualitative data as the supporting data obtained from the interview to find out the portrait of the students’ thinking phase. This research used two classes that were class A as the control class that consisted of 43 students and class B as the experimental class which consisted of 41 students. Then, both classes were given pre-test and post-test which has provided the indicators of conjecturing skills in it.

The research design in the figure 2 showed that two groups were selected randomly (R). Those two groups were given different treatments. In the experimental and control
class applied research based learning methods and the experiment class will use student worksheet.

| Class       | Pre-Test | Treatment                  | Post-test |
|-------------|----------|-----------------------------|-----------|
| Experiment  | R₁       | Student worksheet and RBL   | R₂        |
| n = 41      |          |                             |           |
| Control     | R₃       | RBL                         | R₄        |
| n = 43      |          |                             |           |

Figure 2. Research methods

2.1. Population
The population of the research were the 3rd semester undergraduate students of mathematics education, University of Jember. The samples were taken randomly that were two classes that consisted of control class with 43 students and experimental class with 41 students.

2.2. Instruments
Instruments used in this research were pre-test, post-test, observation and interview. On the rating scale on pre-test and post-test used 0-100. Whereas, on the observation sheet used a rating scale of 0-4, which was a value of 4 for very conjecture, a value of 3 for conjecture, a value of 2 for less conjecture, and a value of 1 for no conjecture. The interview observation sheet had a rating scale of 0-4 that was validated by experts.

Figure 3. The qualitative and quantitative triangulation model

2.3. Task
The tasks given to students were pre-test, post-test and student worksheet that were in accordance with indicators to measure the students’ conjecturing skills. The tests were given to the control class and experimental class while the student worksheet was only given to the experimental class. The students were asked to look for the chromatic number of the graph and its function. The tasks given to the students were as follow:
Figure 4. Determine the edge label and vertex weight on the graph

\[
W(x_1) = \ldots + \ldots = \ldots
\]
\[
W(x_2) = \ldots + \ldots = \ldots
\]
\[
W(x_3) = \ldots + \ldots = \ldots
\]
\[
W(x_4) = \ldots + \ldots = \ldots
\]

Vertex Weight

Figure 5. Make as many lists of chromatic numbers

| \( P_n \) for \( n \) | (\( \chi_{r-l}^{la} \)) | \( P_n \) for \( n \) | (\( \chi_{r-l}^{la} \)) |
|----------------------|------------------------|----------------------|------------------------|
| \( P_3 \) | 3 | \( P_{14} \) | .. |
| \( P_4 \) | .. | \( P_{15} \) | .. |
| \( P_5 \) | .. | \( P_{16} \) | .. |
| \( P_6 \) | 5 | \( P_{17} \) | 7 |
| \( P_7 \) | .. | \( P_{18} \) | 9 |
| \( P_8 \) | 5 | \( P_{19} \) | .. |
| \( P_9 \) | .. | \( P_{20} \) | .. |
| \( P_{10} \) | 6 | \( P_{21} \) | .. |
| \( P_{11} \) | 5 | \( P_{22} \) | 10 |
| \( P_{12} \) | .. | \( P_{23} \) | 9 |
| \( P_{13} \) | 7 | \( P_{24} \) | .. |

Figure 6. Make groups for chromatic numbers that form arithmetic patterns

- Untuk \( n = 5 \mod 6 \)
- Untuk \( n = \ldots \)

| \( P_n \) for \( n = \ldots \) | (\( \chi_{r-l}^{la} \)) |
|--------------------------------|------------------------|
| \( P_7 \) | 5 |
| \( \ldots \) | .. |
| \( \ldots \) | .. |
| \( \ldots \) | .. |
| \( P_9 \) | 9 |
| \( P_{22} \) | 10 |
| \( \ldots \) | .. |

Figure 7. Determine the function of chromatic number

- Untuk \( n = 5 \mod 6 \)
- Untuk \( n = \ldots \)

| \( P_n \) | (\( \chi_{r-l}^{la} \)) | \( f(\chi_{r-l}^{la}) \) |
|----------------------|------------------------|------------------------|
| \( P_{11} \) | 5 | 11 + 4 |
| \( P_{17} \) | 7 | 17 + 4 |
| \( P_{23} \) | 9 | 23 + 4 |
| \( P_n \) | \( n + 4 \) | \( n + 4 \) |

Figure 8. Write down the general function of chromatic number in the graph

\[
\chi_{r-l}^{la} = \left\{ \begin{array}{ll} 
\frac{n}{3} & n = 3, 4 \\
\frac{n}{3} & n = 5 \\
\frac{n}{3} + \cdots & n = \ldots \\
\frac{n}{3} + \cdots & n = \ldots \\
\frac{n}{3} + \cdots & n = \ldots \\
\end{array} \right. 
\]
2.4. Data Collection And Data Analysis
Quantitative data analysis used t-test while qualitative data used interview, observation, and used ordinal data. The qualitative and quantitative data analysis was using descriptive and inferential statistics. The statistical data were obtained from the average, standard deviation and frequency values, while inferential data related to research based learning was using normality test, homogeneity test and independent test between the control class and the experimental class. Independent samples were used to compare the two classes, with a significance value of the difference at the 0.05 level.

3. Research Finding
The initial research was carried out by qualitative method, namely the test of validity and reliability in post-test questions that would be tested to students. The purpose of the validity and reliability tests was to determine the extent of the accuracy of the measurement instrument in performing its measuring function. The following was the results of validity and reliability tests that had been carried out by the research subject. The samples used in the validity and reliability test were 45 students.

Table 2. Results of question validity

| PROBLEM   | PROB_1 Pearson Correlation | PROB_2 Pearson Correlation | PROB_3 Pearson Correlation | PROB_4 Pearson Correlation | PROB_5 Pearson Correlation | SCORE_TOT AL Pearson Correlation |
|-----------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|---------------------------------|
| PROBLEM_1 | .510**                      | .579**                      | .338*                      | .699**                      | .313*                      | .579**                          |
| Sig. (2-tailed) | .000                      | .000                      | .023                      | .000                      | .036                      | .036                           |
| N | 45                          | 45                          | 45                         | 45                         | 45                         | 45                              |
| PROBLEM_2 | -.233                       | .027                       | -.205                      | .205                       | .313*                      | .313*                           |
| Sig. (2-tailed) | .124                      | .859                      | .177                      | .360                      | .036                      | .036                           |
| N | 45                          | 45                          | 45                         | 45                         | 45                         | 45                              |
| PROBLEM_3 | -.114                       | -.201                      | 1                          | .460**                     | -.205                      | .338*                           |
| Sig. (2-tailed) | .455                      | .187                      | .001                      | .177                      | .023                      | .023                           |
| N | 45                          | 45                          | 45                         | 45                         | 45                         | 45                              |
| PROBLEM_4 | .086                       | .058                       | .460**                     | 1                          | .140                      | .699**                          |
| Sig. (2-tailed) | .573                      | .704                      | .001                      | .360                      | .000                      | .000                           |
| N | 45                          | 45                          | 45                         | 45                         | 45                         | 45                              |
| PROBLEM_5 | .464**                      | 1                          | -.201                      | .058                       | .027                      | .579**                          |
| Sig. (2-tailed) | .001                      | .187                      | .704                      | .859                      | .000                      | .000                           |
| N | 45                          | 45                          | 45                         | 45                         | 45                         | 45                              |

**. Correlation is significant at the 0.01 level (2-tailed).
* . Correlation is significant at the 0.05 level (2-tailed).

From the output on table 2, the value of the \( r_{\text{count}} \) on question 1 was 0.510; \( r_{\text{count}} \) on question 2 was 0.579; \( r_{\text{count}} \) on question 3 was 0.338; \( r_{\text{count}} \) on question 4 was 0.699 and \( r_{\text{count}} \) on question 5 was 0.313 while \( r_{\text{table}} \) for \( n = 45 \) was 0.288. So that it can be concluded that \( r_{\text{count}} \) on question 1-5 > \( r_{\text{table}} \) thus all questions were valid. Based on table 3, the reliability value was 0.651 and \( r_{\text{table}} \) from the significance level was 0.05 with dk = N – 1 = 44, \( r_{\text{table}} = 0.291 \). therefore \( r_{\text{count}} > r_{\text{table}} \) thus the instruments were reliable.
Pre-test and post-test data were taken from the control class and the experimental class. The application of quantitative data analysis was by conducting t-test while the qualitative data used interview, observation, and ordinal data analysis. Descriptive and inferential data were used to analyze qualitative and quantitative data. Statistical data were obtained from the average value, standard deviation, and frequency. Inferential data were obtained from the normality test, homogeneity test and independent test carried out in the control class and experimental class. The two classes got different treatments; the experimental class used the research based learning with student worksheet while the control class used the research based learning without student worksheet. In the experimental class used learning the student worksheet based on research based learning method then analyzed with regression tests. Independent samples were used to compare the two classes with a significant value difference at the 0.05 level.

Table 3. Test of the results of question reliability

| Item | Scale Mean if Item Deleted | Scale Variance if Item Deleted | Corrected Item-Total Correlation | Cronbach's Alpha if Item Deleted |
|------|---------------------------|--------------------------------|---------------------------------|--------------------------------|
| PROBLEM_1 | 23.1778                  | 16.468                         | .331                            | .627                           |
| PROBLEM_2 | 23.3778                  | 15.831                         | .411                            | .605                           |
| PROBLEM_3 | 23.5333                  | 18.027                         | .162                            | .668                           |
| PROBLEM_4 | 23.7778                  | 19.436                         | .568                            | .562                           |
| PROBLEM_5 | 23.7778                  | 18.086                         | .110                            | .683                           |
| TOTAL_SCORE | 13.0444                  | 4.953                          | 1.000                           | .213                           |

The results of this research were pre-test and post-test in the control class and experimental classes from the total 84 students. Pre-test was used to determine students' initial conjecturing skills in local antimagic vertex dynamic coloring problems. The pre-test questions contained local antimagic vertex dynamic coloring problems and consisted of 7 indicators of conjecturing skills. While the post-test consisted of 5 questions in which measured the students' conjecturing skills after learning by using student worksheet based on research based learning method through student worksheets. Based on the pre-test results, the control class and the experimental class had the same variance.

From the total 84 students who took the pre-test in the control class, the percentage of each indicator was 60.46% for observing the case indicator (LV 1), 54.94% for organizing the case indicator (LV 2), 56.10% for finding and predicting the pattern (LV 3), 53.49% for formulating the conjecture indicator (LV 4), 54.65% for validating the conjecture indicator (LV 5), 58.14% for generalizing the pattern indicator (LV 6), 55.23% for validating the conjecture indicator (LV 7). Whereas, the results of each indicator analysis in the experimental class were 56.94% for observing the case indicator (LV 1), 50.56% for organizing the case indicator (LV 2), 50.83% for finding and predicting the pattern indicator (LV 3), 48.33% for formulating the conjecture indicator (LV 4), 48.33% for validating the conjecture indicator (LV 5), 51.67% for generalizing the pattern indicator (LV 6), 51.11% for validating the conjecture indicator (LV 7).
The results of the overall pre-test analysis showed that the students' conjecturing skills were categorized into four, which were less conjecturing, quite conjecturing, conjecturing and very conjecturing. Based on the results of the analysis, the percentage of the control class was as follows: 29% was in less conjecturing category, 33% was in quite conjecturing category, 24% was in conjecturing category, and 14% was in very conjecturing category. Whereas, in the experimental class was 28% in less conjecturing category, 35% in quite conjecturing category, 23% in conjecturing category and 14% in very conjecturing category.

Chart 1. The chart of pre-test percentage of each indicator

Chart 2. The distribution of student conjecturing skill in control class

Based chart 3 whereas, in the experimental class was 28% in less conjecturing category, 35% in quite conjecturing category, 23% in conjecturing category and 14% in very conjecturing category. The next step was analyzing data obtained from pre-test and post-test by using SPSS. The data analysis that would be carried out was a quantitative method. The statistical tests performed on both classes were normality test, homogeneity test and independent test. The first step in the analysis by using SPSS was the homogeneity test of both classes to find out whether or not the abilities of both classes were the same.
Table 4. The results of normality test of pre-test in the control class and the experimental class

| Tests of Normality | Kolmogorov-Smirnova | Shapiro-Wilk |
|-------------------|---------------------|-------------|
| Score             | Statistic df Sig.   | Statistic df Sig. |
| Control Class     | .133 43 .056 .970 43 .314 |
| Experiment Class  | .112 41 .200* .974 41 .456 |

a. Lilliefors Significance Correction
* This is a lower bound of the true significance.

The second step was normality test. The mean in the control class was 54.34 while in the experimental class was 59.92. The standard deviation in the control class was 1.2609E1 and 1.3642E1 in the experimental class. Based on the results of normality test of the pre-test data, the kolmogorov-smirnov table 4 showed a significant value of the control class of 0.056 and the experimental class of 0.200. Because the significance of both data was higher than 0.05, it can be concluded that both classes were normally distributed.

Table 5. The results of mean pre-test tests in the control class and experimental class

| Group Statistics |
|------------------|
|                 |
| Class           | N  | Mean  | Std. Deviation | Std. Error Mean |
| Score           |    |       |                |                 |
| Control Class   | 43 | 54.3488 | 12.60930       | 1.92290          |
| Experiment Class| 41 | 59.9268 | 13.64256       | 2.13061          |

Table 5 statistical test result showed the mean of each groups of control class that was 54.34 and the experimental class of 59.92 where the average of the control class was lower than the experimental class.
Table 6. The Results of independent test of pre-test tests in the control class and experimental class

| Independent Samples Test |
|--------------------------|
| Levene's Test for        |
| Equality of Variances    |
| t-test for Equality of Means |
| F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference |
|---|------|---|----|-----------------|-----------------|---------------------|------------------------------------------|
| Equal variances assumed  | .393 | .532 | 1.947 | 82 | .055 | -5.57799 | 2.86459 | 11.27658 | .12060 |
| Equal variances not assumed | .8070 | 6 | 1.944 | .055 | -5.57799 | 2.87003 | 11.28857 | .13277 |

Based on the result of independent test in table 6, we obtained the significance value of 0.532. Because the significance was higher than 0.05, it can be concluded that the pre-test of the control class and the experimental class had the same variance. There value of sig (2-tailed) was 0.055. The value of t > t table and P value was higher than 0.05, it means that there was no different between the control and experimental classes.

After conducting pre-test and giving different treatment, post-test was conducted to know the students’ achievement after the learning process. The post-test consisted of 5 questions of local antimagic vertex dynamic coloring attached with 7 indicators of conjecturing skills. From the total 84 students who did the pre-test in the control class, it obtained the percentage of each indicator were 65.98% for observing case indicator (LV1), 62.5% for organizing case indicator (LV2), 63.95% for finding and predicting pattern indicator (LV3), 59.59% for formulating conjecture indicator (LV4), 61.63% for validating conjecture indicator (LV5), 64.53% for generalizing pattern indicator (LV6), 65.11% for correcting conjecture (LV7). Besides, the result of each indicator analysis in the experimental class was 66.94% for observing the case indicator (LV1), 62.22% for organizing the case indicator (LV2), 62.22% for finding and predicting the pattern indicator (LV3), 61.94% for formulating the conjecture indicator (LV4), 58.33% for validating the conjecture indicator (LV5), 63.89% for generalizing the pattern indicator (LV6), 63.33% for correcting the conjecture indicator (LV7).

Chart 4. The Analysis of post-test result from each indicator
Based on the analysis result of students’ post-test, it obtained the percentage of the control class was 21% in the category of less conjecturing, 29% in the category of quite conjecturing, 27% in the category of conjecturing and 23% in the category of very conjecturing.

**Chart 5.** The distribution of student conjecturing skill in control class

![Post-test of Conjecturing Skill in Control Class](image)

|          | Low Level | Fair Level | High Level | Very High Level |
|----------|-----------|------------|------------|-----------------|
| 1A       | 8         | 12         | 12         | 8               |
| 1B       | 8         | 10         | 12         | 8               |
| 2A       | 10        | 14         | 12         | 8               |
| 2B       | 8         | 14         | 11         | 6               |
| 3A       | 9         | 13         | 12         | 11              |
| 3B       | 9         | 13         | 11         | 11              |
| 4A       | 10        | 13         | 12         | 10              |
| 4B       | 11        | 14         | 10         | 11              |
| 5A       | 9         | 15         | 10         | 11              |
| 5B       | 6         | 15         | 8          | 10              |
| 6A       | 6         | 10         | 8          | 10              |
| 6B       | 4         | 12         | 10         | 10              |
| 7A       | 7         | 10         | 12         | 13              |
| 7B       | 5         | 10         | 10         | 12              |

Based on chart 6, in the experimental class, it was 14% in the category of less conjecturing, 27% in the category of quite conjecturing, 32% in the category of conjecturing, and 27% in the category of very conjecturing.

**Chart 6.** The distribution of student conjecturing skill in control class

![Post-test of Conjecturing Skill in Experiment Class](image)

|          | Low Level | Fair Level | High Level | Very High |
|----------|-----------|------------|------------|-----------|
| 1A       | 5         | 6          | 13         | 12        |
| 1B       | 3         | 10         | 13         | 12        |
| 2A       | 5         | 10         | 11         | 9         |
| 2B       | 5         | 10         | 10         | 9         |
| 3A       | 7         | 12         | 15         | 13        |
| 3B       | 7         | 12         | 13         | 13        |
| 4A       | 7         | 12         | 14         | 15        |
| 4B       | 5         | 12         | 15         | 13        |
| 5A       | 6         | 10         | 13         | 15        |
| 5B       | 5         | 10         | 10         | 10        |
| 6A       | 6         | 9          | 12         | 12        |
| 6B       | 4         | 10         | 12         | 10        |
| 7A       | 4         | 10         | 12         | 9         |
| 7B       | 4         | 12         | 12         | 9         |

The mean score of the control and experimental classes were 63.14 and 69.58 respectively. In Table 7, the result of normality test in the control and experimental classes was normally distributed because the significance value of the control class was 0.200 and the experimental class was 0.200 > 0.05, therefore both data had normal distribution.
Table 7. The result of normality test of post-test in the control and experimental classes

| Class               | Kolmogorov-Smirnov* | Shapiro-Wilk |
|---------------------|----------------------|--------------|
| Control Class       | .087                 | .978         |
| df                  | 43                   | 43           |
| Sig.                | .200                 | .583         |
| Experiment Class    | .077                 | .979         |
| df                  | 41                   | 41           |
| Sig.                | .200                 | .642         |

* Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Table 8 statistical test result showed the mean of each groups of control class that was 63.14 and the experimental class of 69.58 where the average of the control class was lower than the experimental class.

Table 8. The result of mean of post-test in the control and experimental classes

| Class               | N     | Mean   | Std. Deviation | Std. Error Mean |
|---------------------|-------|--------|----------------|-----------------|
| Control Class       | 43    | 63.1395| 11.20073       | 1.70809         |
| Experiment Class    | 41    | 69.5854| 10.23224       | 1.59801         |

Based on table 9 the data of post-test analysis through homogeneity test in the control and experimental classes has homogeneous distribution with the value of sig. 0.681 > 0.05. Because the significance was higher than 0.05, it can be conclude that pre-test from the control and experimental classes had the same variance.

Table 9. The result of independent test of post-test in the control and experimental classes

| Score               | Levene's Test for Equality of Variances | t-test for Equality of Means | 95% Confidence Interval of the Difference |
|---------------------|----------------------------------------|------------------------------|----------------------------------------|
|                      | F          | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower   | Upper   |
| Equal variances      | .170       | .681            | 82              | .007                | -6.44583| 2.34415 | 11.10910 | -1.78256 |
| assumed              |            |                 |                 |                     |         |         |         |
| Equal variances      |            |                 |                 |                     |         |         |         |
| not assumed          | .256       | .815            | 81.85           | .007                | -6.44583| 2.33906 | 11.09910 | -1.79257 |
|                     |            |                 |                 |                     |         |         |         |

The result of independent test obtained variance with with sig. (2-tailed) 0.007 < 0.05. It can be concluded that the result of post-test between the control and experimental classes was significantly different after the implementation of research-based learning.
Based on the result of normality test, the homogeneity and independent t-test in the given pre-test by using SPSS revealed that there was no significant different between the control and experimental classes it mean $H_0$ be accepted. Therefore, it can be concluded that the post test results between the control class and the experimental class have significant differences after applied student worksheet based on research based learning.

The following were the analysis of students’ works in finding local antimagic vertex dynamic coloring in order to know the solving process from LKM so the students find the final result. Analysis of the results of student work is done to support that the information given in the interview is in accordance with his work.

**Figure 9.** The result of student 1 (High Conjecturing Skill)

Figure 9 was the result of student 1 in finding the edge’s label and the vertex’s weight from graph $P_4$. Student 1 named every vertex with $x_1, x_2, x_3,$ and $x_4$. Then, he looked for the color of those edges of the graph. In order to find out the minimum color used to color the vertexs on the graph, student 1 composed any possibilities as shown on figure 9. The requirement of local antimagic vertex dynamic coloring was 1) for two adjacent vertexs which were $u$ and $v$, so $w(u) \neq w(v)$ in which $w(u) = \sum_{e \in E(u)} f(e)$ the edge seat around $u$ was $E(u) : 2)$ said to be dynamic r-vertex coloring if $|c(N(v))| \geq \min\{r, d(v)\}$ every adjacent vertex had different color. The first requirement of local antimagic vertex dynamic coloring had been fulfilled by student 1.

After the students finishing the problem which related to local antimagic vertex dynamic coloring, the researcher conducted interview for mind mapping in solving the
problem about local antimagic vertex dynamic coloring. This interview aims to find out the student's frame of mind when solving local antimagic vertex dynamic coloring problems.

The excerpt of the interview was explained as follows:

Researcher : After reading this problem, what do you understand?
Student 1 : At first I didn't understand it. But after solving the problems in the LKM, I understand. The problem that I have to solve is to find the local antimagic dynamic vertex from the graph.

Researcher : Did you find it?
Student 1 : Yes ma'am.

Researcher : What is the first step you take to resolve this problem?
Student 1 : I guessed first mom, about anywhere I can set the label on its edge to be a minimum vertex weight. After I found the vertex weight, I just searched for the cardinality of the graph first and then labeled the coloring on the edge of the graph according to the resolution of the local antimagic vertex dynamic coloring so that it adds a minimum point. Then I check if the point weights that I have found have met the requirements by creating a table like this. After that, I look for chromatic numbers if the graph is expanded. And finally I look for a function of chromatic numbers.

Researcher : What are the ways you use to make it easier for you to solve this problem?
Student 1 : I made various possibilities to find a minimum vertex weight and make a table to test whether my job has fulfilled dynamic requirements or not.

Researcher : Do you have difficulty in solving this problem?
Student 1 : Yes miss.

Researcher : What difficulties did you experience?
Student 1 : Make the function miss, because finding the pattern must be careful and patient in my opinion.

Figure 10. The phase portrait of student 1

Figure 10 showed the student’s thinking process in solving the problem, related to local antimagic vertex dynamic coloring. The first step start from 3a, revealed that student 1 on stage 3b had the repetition to stage 1a, then he jumped from stage 1a to 3a.

The following are the results of interviews with students 2:

Researcher : After reading this problem, what do you understand?
Student 2 : Local antimagic vertex dynamic coloring.

Researcher : Did you find it?
Student 2 : I can find a bu for local antimagic vertex dynamic coloring, but I can't find its function.
Researcher : What is the first step you take to resolve this problem?
Student 2 : Yes I specify the cardinality to continue labeling the graph edge coloring until the vertex weight is minimal. In order for me to be able to expand the graph and find the minimum color, I would repeatedly draw the graph. I also found the local antimagic vertex dynamic coloring chromatic number of all the results of the expanse.

Researcher : Do you have difficulty in solving this problem?
Student 2 : I don’t know how to make the function, I’m a little confused, mom.

Figure 11. The result of student 2 (Fair Conjecturing Skill)

In accordance with Figure 12, student 2 showed that student 2 had the repetition on stage 3a back to 1a.

Figure 12. The Phase Portrait of Student 2

The following are the results of interviews with students 3:
Researcher : After reading this problem, what do you understand?
Student 3 : Local antimagic vertex dynamic coloring
Researcher : Did you find it?
Student 3 : No ma’am
Researcher : What is the first step you take to resolve this problem?
Student 3 : Draw the graph, label the edges and vertex weights, name the graph and look for the cardinality. I labeled the edge with a 1-5 number because the
number of edges is 5 and weights the number 1-6 because the number of vertex is 6.

Researcher: How do you put all the numbers?
Student 3: I put the edge coloring label randomly, so does the point.
Researcher: Do you have difficulty in solving this problem?
Student 3: A little
Researcher: What difficulties did you experience?
Student 3: I was confused about how to finish it so I ran out of time and my work was not finished.

Figure 13. The result of student 3 (low conjecturing skill)

Based on figure 14, it drew that student 3 solve problems with coherence in accordance with the order of existing sub indicators.

Figure 14. Potret Phase Mahasiswa 3

Figure 15. The combination of phase portrait from student 1, 2, and 3

RBL activities and conjecturing skills indicators that have been published on the student worksheets aim to train student conjecture skills and at the same time become
research steps in the study of local antimagic vertex dynamic coloring. While the final assignment given in the student worksheet aims to find new findings in the study of local antimagic vertex dynamic coloring. All student findings will be summarized in a monograph.

Based on observations on student activities in resolving local antimagic vertex dynamic coloring through the application of research-based learning that there is a significant impact of the implementation of research-based learning in improving student conjecturing skills in solving local antimagic vertex dynamic coloring problems. This is in line with [11] the study found that there was a significant effect of the implementation of research-based learning on student achievement.

| Very Inactive | 2 | 2 | 3 | 2 | 3 |
| Inactive | 2 | 4 | 2 | 3 | 3 |
| Hasitate | 6 | 5 | 6 | 5 | 5 |
| Active | 17 | 14 | 17 | 16 | 18 |
| Very Active | 14 | 16 | 13 | 15 | 12 |

**Chart 7. The Distribution Student Activities during RBL Implementation**

Student activity shows positive results. Distribution of student activities during the implementation of research-based learning in the experimental class shows 6% of students are very inactive, 7% of students are inactive, 13% of students are hesitant, 40% of students are active, 34% of active students are very active. Facts show the linearity of this study with other studies on implementation or research-based learning [10].

4. **Discussion**

This study aims to analyze the implementation of research-based learning (RBL) on skills that contain student expectations in resolving local antimagic vertex dynamic coloring problems. This research was conducted to analyze. The findings of this study indicate that the research conducted on this study has significant significance on the alleged ability of students in the experimental class.

The results showed that the improvement in learning outcomes and students' thinking skills were seen in the post-test. The experimental class scores were significantly better than those supported by student worksheet based on RBL to improve students' conjecturing skills. The results of the research obtained in the control class are as follows was 21% in the category of less conjecturing, 29% in the category of quite conjecturing, 27% in the category of conjecturing and 23% in the category of very conjecturing. Whereas, in the experimental class, it was 14% in the category of less conjecturing, 27% in the category of quite conjecturing, 32% in the category of conjecturing, and 27% in the category of very conjecturing.
The independent test results obtained variance the sig value. (2-tailed) 0.007 < 0.05. It can be concluded that the posttest results between the control class and the experimental class have significant differences after applied research based learning. The results of the study are in line with the theory conveyed by [3] that the research data based learning method greatly helps students to pass the predetermined value target. These results achieved by the experimental class show that learning objectives play an important role in solving student problems. The final ability is expected that students achieve values in accordance with standards, improve new skills, improve or develop competencies, try to solve something challenging and try to gain understanding and knowledge [10]. Research based learning should be applied in many departments to expand research in all institutions, and to apply research in education, the relationship between research and teaching [9].

5. Conclusion
Based on the results of the research that has been done, the application of RBL has a significant influence on the students' conjecturing skills in the experimental class. The results showed an increase in learning outcomes and students' thinking skills seen from the post-tests conducted. The experimental class produces better grades because it implements learning-based learning (RBL) in improving students' conjecturing skills. Therefore RBL learning is very good for improving students' conjecturing skills.

Acknowledgements
We gratefully acknowledge the support from The Head of Math Education Magister department and the Dean of Faculty of Teacher Training and Education, University of Jember Indonesia, and CEREBEL Research Groups.

References
[1] Arumugam S, Premalatha K, Baca M and Semanicova F 2007 Local Antimagic Vertex Coloring of a Graph *Graphs and Combinatorics* 33 275-285
[2] Cañadas MC, Deulofeu J FL, Reid D, & Yevdokimov O 2007 The Conjecturing Process: Perspectives in Theory and Implications in Practice *Journal Of Teaching and Learning* 5 55-72.
[3] Fatimah IS, Anas AK 2018 Incorporating Research in Chemistry Courses: Research Data-Based Learning *International Journal of Engineering & Technology* 7 229 476-479
[4] Hobri, Dafik, & Hossain A 2018 The Implementation of Learning Together in Improving Students’ Mathematical Performance *International Journal of Instruction* 11(2) 483-496
[5] Khamdit, Sinthawa 2014 Research–Based Learning (RBL) in Higher Education
[6] Kristiana Al, Utoyo MI, Dafik, Alfarisi R, Agustin IH Local Antimagic R-dynamic Coloring of Graph *International Journal of Engineering of Graph* in press
[7] Mason J, Burton L, & Stacey K 2010 Thinking Mathematically Second Edition *Pearson Education Limited*
[8] Poonpan S and Siriphan S 2001 Indicators of Research-Based Learning Instructional Prosess : A Case Study of Best Practice in a Primary School *Disertasi Faculty of Education* Chulalongkorn University Phaya Thai. Bangkok, Thailand
[9] Schapper J, & Mayson SE 2010 Research-led Teaching: Moving from a Fractured Engagement to a Marriage of Convenience *Higher Education Research & Development* 29 641-651.
[10] Schunk DH 2012  Learning Theories and Educational Perspective Sixth Edition (6th Edition of Learning: Perspective) Edition Sixth Edition Yogyakarta Student Literature

[11] Suntusia, Dafik, Hobri 2018 The Effectiveness Research Based Learning in Improving Students Achievement in Solving Two-Dimensional Arithmetic Sequence Problems Internasional Journal of Instruction 12 17-32

[12] Sutarto N, Subanji T, & Sisworo 2015 Indicator of Conjecturing Process in a Problem Solving of The Pattern Generalization Proceeding International Conference on Educational Research and Development (ICERD) UNESA Surabaya 32-45.

[13] Sutarto S, Nusantara, T,Subanji, S, Dwi H, Dafik 2018 Global Conjecturing Process in Pattern Generalization Problem Journal of Physic: Conference Series 1008(1)