The development of the implementation of discovery learning and the influence to the student’s conjecturing ability to solve local irregularity vertex coloring in graphs

N Nikmah\textsuperscript{1,2}, A I Kristiana\textsuperscript{1,2}, Dafik\textsuperscript{1,2}, Hobri\textsuperscript{1,2} and Slamin\textsuperscript{1,3}

\textsuperscript{1}CEREBEL University of Jember, Indonesia
\textsuperscript{2}Department of Mathematics Education Post Graduate, University of Jember, Indonesia
\textsuperscript{3}Department of Informatics. University of Jember, Indonesia

Email: nafidatun.nikmah@gmail.com

Abstract. This research aims to explain about development of the implementation of discovery learning and the influence of student’s conjecturing ability to solve local irregularity vertex coloring in graphs. Discovery learning is one of the learning models that can be used to improve the ability of students to conjecture in solving mathematical problems. For processing of data their conjecturing ability using triangulation methods, namely a combination of qualitative and quantitative methods. Students majoring in Mathematics Education at Jember University are research subjects. Subjects of this research using experimental class and control class. Different treatments are offered to both class. This research results findings indicate that there is a major gap between both class implementing discovery learning and teacher centered learning.

1. Introduction
In many sectors, developments have been made in science and technology (IPTEK) changes in various especially education. Education is one of the major factors in a country’s development, especially university level education, because it has a strategic role in increasing of Human Capital. In fact, education has recently been preferred in required to be allowed to improve and develop all the current student skills [1]. Conjecturing skills are one of the skills expected to be improved. Conjecturing skills that students use to solve mathematics problems. The functions of mathematics are to learn the ability to count, calculate, find or use mathematical formulas that can support the understanding of the concepts of students in their actual routine, such as business, economics, engineering and others [1].

Moreover, mathematics has to do with solving problem. Problem solving and conjecturing are major elements of mathematics practices. Researchers have indicated that problem solving and conjecture are essential components of mathematical practices. Problem solving is part of school mathematics standards [2]. He explained further that the development of new knowledge and further research, including the information of conjectures, is necessary for mathematical thought and reasoning abilities. Conjecture plays a role when it comes to mathematics namely: (1) conjecture as a way to solve problems (2) conjecture as a process which helps students understand the material, and (3) conjecturing as a reasoning phase for students [3][4].

In fact, the educators find it difficult to teach conjecturing thinking skills. The process of learning mathematics in the field still uses conventional learning, an educators who actively teaches mathematics, then gives examples and exercises, students function like machines only listening, writing, and doing...
exercises. Exploration of early students knowledge was not carried out. Responding to these problems, student centered learning is needed, namely discovery learning. The reason for choosing this model of learning is that it offers the students the ability to learn and find formulas or ideas from the content they research [5]. This learning concept places educators as facilitators. Educators guide students when they are needed. Students are allowed to think for themselves, investigate themselves to “find” general concepts bases of the supplied material or data [6].

“Discovery Learning is an inquiry-based approach which students are given a question to answer, a problem to solve, or collection of observations to explain, and then work in a largely self-directed manner to complete their assigned task and draw appropriate inferences from the outcomes, discovering the desired factual and conceptual formations in the process” [5][7]. One of the characteristics of in discovery learning is that students develop awareness of new information and data collected by them in an explorative learning environment [5][8]. There are six procedures to be followed in learning activities to implement discovery learning, namely: 1) Stimulation, 2) Problem statement, 3) Data collection, 4) Data processing, 5) Verification and 6) Generalization [5][9].

The Conjecturing process carried out this study includes the conjecturing empirical induction from finite numbers in discrete cases. Seven conjecturing indicators exist. The seven indicators can be divided into sub-indicators, which are as follows: 1) observing the problem (ID 1) with the sub-indicator: students draw the graph (ID1A) and name the graph (ID1B); 2) organizing the problem (ID 2) with the sub-indicator: students give label in the graph (ID2A) and predict to solve the problem (ID2B); 3) Finding and Predicting (ID3) with the sub-indicator: students investigate information based on the problem (ID3A) and determine the local irregularity vertex coloring in graphs (ID3B); 4) formulating the conjecture (ID 4) with the sub-indicator: students determine the pattern of local irregularity vertex coloring in graphs (ID4A) and clarify the local irregularity vertex coloring (ID4B); 5) validating the conjecture with the indicator students test the working (ID5); 6) generalizing the conjecture with the indicator students determine the generalization of the local irregularity vertex coloring (ID6); 7) validating the conjecture (ID 7) with the sub-indicator: students validate the generalization of the pattern (ID7A) and students compare the working (ID7B) [5][10][11]. This study aims to improve discovery learning and its effect on student’s conjecture abilities in the local irregularity vertex coloring of a graph [5].

The content used for this research is local irregularity vertex coloring of a graph. Let $G(V, E)$ be graph with set vertices $V$ and set edges $E$. A vertex irregular $k$-labelling $l:V(G)\rightarrow \{1, 2, 3, ..., k\}$ is defined by a local irregularity vertex coloring $l$ if $\text{opt}(l) = \min\{\max(l_i): l_i \text{ vertex irregular labelling}\}$. The minimum cardinality of local irregularity vertex coloring of $G$ is called chromatic number local irregular denoted by $\lambda_{ir}(G)$ [12]. Local irregularity vertex coloring is one of the subjects in graph theory. Arika first raised the problem of releasing the local irregularity vertex coloring [12]. Arika introduces the lemma and definition of local irregularity vertex coloring. This topic was then established some families graph [13], related wheel graph [14], related grid graph [15]. Discovery learning has also been developed by various of previous researchers, including a list of researchers are Azizah[16], Anggraeni [17], Trawiki [18].

2. Methodology
This research is kind of a mixed method of research which blends quantitative with qualitative methods. The quantitative data from the test compiled are based on the students’ indicator of the conjecture of the local irregularity vertex coloring in the graph. Data collection from students interview results supported by qualitative data to describe the portrait phase of students thought. Students of Mathematics Education Study Program, University of Jember, are the center of this research.

2.1. Population
This research has two categories, class A as the control class of 34 students and class B as the experimental class of 28 students. Then, the same pre-test and post-test are given to both classes, that are compiled based on the conjecture abilities indicator. Different forms of treatment for both classes.
The teacher centered learning will be applied in the control class and discovery learning will be applied and the student worksheets will be used in the experimental class. The successful result can be seen after the solution of the worksheets.

| Class          | Pre-Test | Treatment                  | Post-Test |
|----------------|----------|----------------------------|-----------|
| Experiment, n = 28 | R₁       | Discovery learning         | R₂        |
| Control, n = 34  | R₃       | Teacher centered learning  | R₄        |

2.2. **Instrument**

Pre-testing, post-testing, observing and interviewing were the instruments. In this research, the rating scale used 0-100 on pre-test and post-test. In the meantime, observation and interview sheets with 0-3 rating intervals validated by experts are appropriate. Scale rating 3, high conjecture; scale rating 2, conjecture; scale rating 1, fewer conjecture; and scale rating 0, no conjecture. An overview of the research procedure is seen in the diagram below.

**Figure 1.** Diagram of Mixed-Method.
2.3. Task
The tasks given by teachers are first, pretest; secondly, worksheets; and the last, posttest. All the tasks according to the indicator students are conjecturing abilities. The control class and the experimental class were given the same examination, while the worksheets were given only to the experimental class. All tasks, students were asked to determine the coloring of the local irregularity vertex on graph.

2.4. Collection and analysis of data
In this research, the analysis of quantitative data required inferential statistics such as the validity test, the reliability test and the normality test using SPSS and Microsoft Excel, which are then explored using a Mann Whitney test to see the difference between the two classes, the control class and the experimental class. During the interview and the observation findings analyzed by portrait phase are qualitative data collected.

3. Result and discussion
After checking with validity test and reliability test, the research in the experimental class and the control class was done. Students would then be given a pre-test in the experimental class and the control class to find out the initial conjecture abilities. After the pre-test in control and experimental class, the both classes would learn with details that a discovery learning was taken by the experimental class and teacher centered learning was used by a control class. After implementing the learning model in both classes, the next move was the post-test to find out the final initial of student’s conjecture abilities. The outcome of both classes will then be analyzed using SPSS programs and Microsoft Excel. The following is the product of data analysis using SPSS programs and Microsoft Excel.

3.1. Validation and reliability
The validity and reliability of the instrument must be checked before the result are shown. The instrument is true (valid) if $r$-count $\geq r$-table (Testing 2-edges with sig. 0.01), $r$-count is pearson correlation on table 2. The instrument is considered as valid if sig (2-tailed) < 0.05. The following table shows the result of the validity and reliability of the post-test instrument.

| Correlations | Question 1 | Question 2 | Question 3 | Question 4 | Question 5 | Question 6 | Total Score |
|--------------|------------|------------|------------|------------|------------|------------|-------------|
| Pearson      | .715**     | .479**     | .513**     | .414*      | .472**     | .521**     |             |
| Correlation  |            |            |            |            |            |            |             |
| Sig. (2-tailed) | .000       | .004       | .002       | .015       | .005       | .002       |             |
| N            | 34         | 34         | 34         | 34         | 34         | 34         |             |
| Pearson      | .715**     | .790**     | .775**     | .719**     | .696**     | .802**     |             |
| Correlation  |            |            |            |            |            |            |             |
| Sig. (2-tailed) | .000       | .000       | .000       | .000       | .000       | .000       |             |
| N            | 34         | 34         | 34         | 34         | 34         | 34         |             |
| Pearson      | .479**     | .790**     | .881**     | .861**     | .864**     | .933**     |             |
| Correlation  |            |            |            |            |            |            |             |
| Sig. (2-tailed) | .004       | .000       | .000       | .000       | .000       | .000       |             |
| N            | 34         | 34         | 34         | 34         | 34         | 34         |             |
| Pearson      | .513**     | .775**     | .881**     | .812**     | .825**     | .840**     |             |
| Correlation  |            |            |            |            |            |            |             |
| Sig. (2-tailed) | .002       | .000       | .000       | .000       | .000       | .000       |             |
| N            | 34         | 34         | 34         | 34         | 34         | 34         |             |
| Pearson      | .414*      | .719**     | .861**     | .812**     | 1          | .774**     | .852**      |
| Correlation  |            |            |            |            |            |            |             |
| Sig. (2-tailed) | .015       | .000       | .000       | .000       | .000       | .000       |             |
| N            | 34         | 34         | 34         | 34         | 34         | 34         |             |
Based on the output from Table 2, on question 1 the value of the $r_{count}$ is 0.521; question 2 the value of the $r_{count}$ is 0.802; question 3 the value of the $r_{count}$ is 0.933, question 4 the value of the $r_{count}$ is 0.840, question 5 the value of $r_{count}$ is 0.852, and question 6 the value of $r_{count}$ is 0.917. While $r_{table}$ for $N=34$ is 0.436 and $r_{count} > r_{table}$, and based on table 2 the value of sig (2-tailed) < 0.05, so all question are valid. The instrument is considered as reliable if value of Cronbach’s Alpha > 0.60. Based on table 3, the value of Cronbach’s Alpha is 0.906 and it show Cronbach’s Alpha > 0.60 so that the instruments item are reliable.

Table 3. Reliability Statistics.

| Reliability Statistics |
|-------------------------|
| Cronbach's Alpha        | N of Items |
| 0.906                   | 6          |

Table 4. Test of Normality.

| Tests of Normality |
|---------------------|
| Kolmogorov-Smirnov<sup>a</sup> | Shapiro-Wilk |
|                         |               |
|                         | Statistic | df | Sig. | Statistic | df | Sig. |
| student learning outcomes |          |    |      |            |    |      |
| pre test control        | .249      | 34 | .000 | .826       | 34 | .000 |
| post test control       | .256      | 34 | .000 | .784       | 34 | .000 |
| pre test experiment     | .276      | 28 | .000 | .800       | 28 | .000 |
| post test experiment    | .158      | 28 | .073 | .870       | 28 | .002 |

a. Lilliefors Significance Correction

The data are said to be normally distributed if the significant value is greater than 0.05. While in Table 4 the significant value for pretest data for the experimental and control class is less than 0.05, i.e. 0.000, whereas the posttest data for the experimental class is more than 0.05, i.e. 0.073, but the posttest data for the control class is 0.000. Thus pretest’s data from the control class and the experimental class, the control class posttest, were not normally distributed while the data from the experimental class posttest were normally distributed. Therefore the difference is quantified by Mann
Whitney test in the mean data for the control class and the experimental class. So, there is no criteria for the normal distribution of the data in the Mann Whitney test.

3.2. Result

Different findings were analyzed and the results in two classes with a total of 62 students. The results of the tests done indicate this. The test measures the conjecturing ability of the student to determine local irregularity vertex coloring in the graph. The questions in the pretest include a concern with the irregularity vertex coloring, consisting of seven indicators and the post test.

**Figure 2.** The result of conjecturing skill for pre-test in control class.

From the control class from 34 students, the result of their conjecturing ability after giving pretest shown no conjecture level, because percentage of conjecture level was 100 percent and 0 percent students in the high conjecture level, conjecture level, and fewer conjecture level. We can see from figure 2. After the teacher explain about local irregularity vertex coloring, the teacher gives post test. The result conjecturing ability from post test was 85 percent no conjecture level, 15 percent fewer conjecture, and 0 percent conjecture and high conjecture level. We can see from figure 3.

**Figure 3.** The result of conjecturing skill for post-test in control class.
From the experimental class from 28 students, the result of their conjecturing ability after giving pretest shown no conjecture level, because percentage of conjecture level was 100 percent and 0 percent students in the high conjecture level, conjecture level, and fewer conjecture level. We can see from figure 4. On the experimental class use discovery learning, and the teachers as facilitators. After the teacher gives worksheet about local irregularity vertex coloring, the teacher gives post test. The result conjecturing ability from post test was 4 percent in the no conjecture level, 39 percent in the fewer conjecture level, 0 percent conjecture, and 57 percent high conjecture level. We can see from figure 5.

**Figure 4.** The result of conjecturing skill for pre-test in experimental class.

![Figure 4](image1.png)

**Figure 5.** The result of conjecturing skill for post-test in experimental class.

![Figure 5](image2.png)

After observing the outcome of the control class posttest and the experimental class posttest, the next step was to investigate the quantitative method that used detect the difference between the two classes, the control class and the experimental class. Seeing the use of discovery learning has an affect on the ability of the student to conjecture in graphs to determine local irregularity vertex coloring in. To analyze its use of the Mann Whitney on SPSS. We can see from Table 5.
Based on table 5, Mann Whitney test of post test from control class and experimental class had sig(2-tailed) 0.0000, otherwise it is smaller than 0.05, this indicates that the learning outcomes of control class and experimental class differs. They are different. Therefore the inference is that the use of discovery learning has an effect on local irregularity vertex coloring.

The student study specifies the local irregularity vertex coloring to detect the fulfillment of the worksheet and to find the right result. After the results of the learning have been collected in two classes, the researcher must reach through worksheets given for an analysis of each student’s results. Extracting Information is collected through the execution of students interviews. Potrait phase was required to demonstrate the processes in learning. The potrait phase was representation the processes from conjecturing abilities, we selected six objects from each experimental and control class, and we only represent three subjects as the illustrations in this research. The interview was conducted on selected subjects to evaluate the thought process in completing the local irregularity vertex coloring.

The conjecture abilities of students in solving the local irregularity vertex coloring of a graph show that there is a discrepancy between one subject and another. This disparity in conjecture abilities is due to their expertise and past experience. Based on the results of the interviews and review of the student answer sheets, an outline of each student’s conjecture abilities in solving local irregularity vertex coloring was obtained.

Table 5. Mann Whitney test result of posttest.

| Test Statistics | student learning outcomes |
|-----------------|--------------------------|
| Mann-Whitney U  | 9.500                    |
| Wilcoxon W      | 604.500                  |
| Z               | -6.610                   |
| Asymp. Sig. (2-tailed) | .000                  |

a. Grouping Variable: Class

Figure 6. The result of subject 1.
Figure 6 indicates the outcome of subject 1 (S1). Outcome of subject 1 (S1) of each vertex of the volcano graph (V_6). Each vertex of the graph is labeled by x_1, x_2, x_3, x_4, x_5, x_6 and continued by determination of the graph’s cardinality. Then S1 took the next step to determine the local irregularity vertex coloring of graph V_6. S1 the results of the interviews conducted on the subject S1 showed that S1 understood the intent of the questions. It was evident from the results of the researcher (R) interview with S1 on mind mapping with the problem of local irregularity vertex coloring. This interview has the aim to show the way of thinking and the level of conjecture abilities of students when determining local irregularity vertex coloring. The interview excerpts are as follows:

R : How else are you going to determine the local irregularity vertex coloring of V_6?
S1 : I initially did not understand the coloring of the local irregularity vertex material because I did not get the material, but I eventually learned how to do it after I exercised and practiced on the worksheet that was given.
R : Have you got it?
S1 : Yeah I did that.
R : Can you explain how step by step you find the problem solving in local irregularity vertex coloring?
S1 : First, I drew the graph V_6 and labeled each vertex of the graph. I tried to guess what the minimum color of graph V_6 was and I searched for the cardinality of each vertex and the edge of graph V_6. Next, I’m testing the representation of each vertex. I had to make sure that I find the minimum label for the local irregularity vertex coloring. Finally I found the local chromatic number.
R : What’s the best way to solve this problem?
S1 : I have made many possible answer to decide the minimum label and colour of graph on the graphs.
R : Have you found it hard to solve this problem?
S1 : Yes I did, it was so hard to find a function. I had to find the pattern, and I did it one by one carefully.

![Figure 7. Portrait of the phase of the subject 1 (S1).](image)

Portrait of the phase of the subject 1 (S1) based on Figure 7, illustrated the student’s conjecture abilities in finding a problem solving local irregularity vertex coloring of graph V_6. After drawing (ID 1A) and giving label (ID 2A), S1 skipped the local irregularity vertex coloring statement (ID 3B). Subject 2 (S2) is the next interview:

R : How else are you able to get about the material?
S2 : Is it possible to determine the local irregularity vertex coloring of the graph?
R : Have you got the material?
S2 : No, I didn’t do that. It’s been so hard to get it.
R : What’s the hard thing of the steps you’ve got to do. Can you explain every step of this?
S2 : I drew the graph, labeled for each vertex and the edges of the graph. Next, I named the graph and went on to find the cardinality of each vertex and the edge of graph V_6. Last I tried to determine the local irregularity of the vertex coloring, but I couldn’t find it.
R : Have you found something difficult to solve in the problem?
S2 : Haha I did Miss. It was so hard and frustrating to find the vertex coloring of the local irregularity.

But I haven’t been done yet.

Based on the conversation with S2 while working on the task, a portrait of the phase in the sub indicator is shown as the figure 8.
**Figure 8.** Portrait of the phase of the subject 2 (S2)

Interviews performed on subjects 3 (S3) showed that S3 observed cases by observing cases by drawing graphs and immediately searching for and predicting patterns continued to search for functions to evaluate the local irregularity vertex coloring on graph $V_6$, with the understanding of graphs.

The interview results completed on subject 4 (S4) showed that S4 did not explain the aim of the problem, but S4 knows that graph $V_6$ has the cardinality for each vertex and edge. S4 cannot proceed to the next level, as it does not understand the aim of the problem.

**Figure 9.** Portrait of phase of subject 1, 2, 3, and 4.

Figure 9 displays a mix of multiple portraits phase of S1, S2, S3, and S4. The combined portrait phase will illustrate the conjecturing abilities of students in general, and each student has a distinct and special way of solving a local irregularity vertex coloring problem.

The process of implementing the conjecturing processes in solving the local irregularity vertex coloring as shown in figure 9 can be defined from the description of the results of interviews and analysis of each students response board. The process overview demonstrates how students think based on the steps of the conjecturing process in solving the local irregularity vertex coloring. It only happens online, but the conjecture process also occurs with zigzag as done by S1, S2, S3, and S4 and some do not proceed to the next stage because the subject does not understand the problem.

Following observations made on student activities during the process of the study, the researcher will demonstrate that discovery learning can have an effect on the conjecture abilities and student learning achievement of students in completing the local irregularity vertex coloring. That linearity of this research can be demonstrated by observing the real implementation of discovery learning [5, 16, 17, 18].

**4. Discussion**

In the learning process, students must be stimulated to improve their conjecture abilities in local irregularity vertex coloring. The main objective of this study is to examine the implementation of discovery learning in the conjecture ability of students to solve the problem of chromatic number on local irregularity vertex coloring. The finding is that research classes using discovery learning (experimental class) have big improvement in the ability of students to conjecture. In addition, if bound from the post-test, the results of research performed have seen an improvement in student learning outcomes in the material.

The post-test findings from the experimental class using discovery learning showed a major and better shift in increasing the ability of students to conjecture. The result conjecturing ability from post test was 85 percent no conjecture level, 15 percent fewer conjecture, and 0 percent conjecture and high
conjecture level. Whereas, the result conjecturing ability from post test was 4 percent in the no conjecture level, 39 percent in the fewer conjecture level, 0 percent conjecture, and 57 percent high conjecture level.

This analysis was carried out to evaluate the ability to think conjecture and the application of Mann Whitney post test discovery learning test from control class and experimental class had sig(2-tailed) 0.0000, otherwise it less than 0.05, meaning that the learning outcomes of control class and experimental class vary. Different are they. The assumption is therefore that the use of discovery learning has an effect on local irregularity vertex coloring.

5. Conclusion
The research that has been conducted demonstrates that the proposed of discovery learning has a substantial influence on student conjecture abilities in the experimental class. Students in the experimental class have a better conjecture ability compared to the control classes. The result of the research show that the student’s learning result and conjecture abilities are increasing as shown from the post test. Finally we can suggest that the implementation of discovery learning has a substantial influence on student’s conjecture abilities.

The portrait phase of the students is a picture that explains the flow of the student’s conjecture ability to solve the local irregularity vertex coloring. The gap in thought flow from students in the control class, which has a relatively low flow, and the experimental class, which has relatively high flow, can be identified.

Acknowledgement
This research was funded by DRPM Kementerian Riset dan Teknologi/ Badan Riset dan Inovasi Nasional Republik Indonesia, number 25/E1/KPT/2020 through the Penelitian Dasar scheme year 2020, grant number 175/SP2H/AMD/LT/DRPM/2020 and number 1670/UN25.3.1/LT/2020.

References
[1] Y. Wangguway, Slamin, Dafik, I N Maylisa and S Kurniawati 2019 The analysis of research based learning implementation and its affect to the student’s metacognition skill in solving a resolving domination number of a graph Journal of Physics: Conference Series 1538012087
[2] Nasional Council of Teacher of Mathematics 2000 Principles and Standards for School Mathematics (Reston, VA: NCTM)
[3] Sutarto N, Subanji T and 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
[4] Sutarto S, Nusantara T, Subanji, Hastuti I S and Dafik 2018 Global Conjecturing Process in Pattern Generalization Problem Journal of Physics: Conference Series 1008(1)
[5] S. Kurniawati, Slamin, Dafik, Y. Wangguway and A N Hayya 2019 The analysis of the discovery learning implementation and its affect to the students conjecturing skills in solving a resolving domination number Journal of Physics: Conference Series 1538012097
[6] Kasmiana, Yusrizal, M. Syukri 2020 The application of guided discovery learning model to improve students concepts understanding Journal of Physics: Conference Series 1460
[7] Prince M J and Felder R M 2006 Inductive Teaching and Learning Methods: Definitions, Comparisons and Research Bases Journal of engineering education 95(02) 123–38
[8] De Jong and Van Joolingen W R 1998 Discovery learning with computer simulations of conceptual domains Review of Educational Research 68 179–201
[9] Bruner J S 1966 Some elements of discovery. In Shulman L. S., Keislar, E. R. (Ed.), Learning by discovery: A critical appraisal Chicago: Rand McNally pp 104-111
[10] Cañadas M C, Deulofeu J, Figueiras L, Reid D and Yevdokimov O 2007 The Conjecturing Process: Perspectives in Theory and Implications in Practice Journal Of Teaching and Learning 5(1) 55-72
[11] Wardani P L, Dafik and Tirta I M 2019 The analysis of research based learning implementation in improving students conjecturing skills in solving local antimagic vertex dynamic coloring Journal of Physics: Conference Series 1839 012032

[12] Arika I K, Dafik, M I Utoyo, Slamin, Ridho A, Ika H A, M Venkatachalam 2019 local irregularity vertex coloring of graph International Journal Of Civil Engineering And Technology (IJCIET) volume 10 issue 3 pages 1606-1616

[13] A. I. Kristiana, Ridho Alfarisi, Dafik & N. Azahra 2020 Local Irregular Vertex Coloring Of Some Families Graph Journal of Discrete Mathematical Sciences and Cryptography 1754541

[14] A. I. Kristiana, et al 2019 On The Chromatic Number Local Irregularity Of Related Wheel Graph Journal of Physics: Conference Series 012003

[15] N Azahra, A I Kristiana, Dafik, R Alfarizi 2020 On the Local Irregularity Vertex Coloring of Related Grid Graph International Journal of Academic and Applied Research (IJAAR) volume 4 issue 2 pages 1-4

[16] Azizah S N, Dafik and Susanto 2018 The Effectiveness of Discovery Based Learning Implementation through Improving Students’ Innovative thinking Skills in solving Open Ended Task of Pattern Generalization International Journal of Advanced Engineering Research and Science (IJAERS) 5 pp 74-82

[17] Anggraini D D, Dafik and Slamin 2019 The analysis of implementation of discovery learning to improve student’s creative thinking skill in local super antimagic total face coloring problem Journal of Physics: Conference Series 1211 012087

[18] Trawikhi A, Hobri, Prihandoko A C and Utomo B T 2019 Development of mathematical learning tools through discovery learning based on lesson study for learning community and their influence with students’ problem solving Journal of Physics: Conference Series 1211 012082

[19] Joolingen W V 1999 Cognitive Tools For Discovery Learning International Journal of Artificial Intelligence in Education 10, 385-397