The analysis of implementation of research based learning implementation in developing the students’ creative thinking skill in solving dominating set problem

M A Rohim¹*, Dafik², Slamin³, B Sucianto⁴
¹CGANT UNEJ, University of Jember, Indonesia
²Department of Postgraduate Mathemathic Education, University of Jember, Jember, Indonesia
³Department of Elementary School Education, University of Jember, Jember, Indonesia
⁴CGANT UNEJ, University of Jember, Indonesia

Email : ah.rohim21@gmail.com and d.dafik@unej.ac.id

Abstract. Study aims to understand the effectiveness of research-based learning in improving learning outcomes of the students in dominating set problem. This research used a triangulation method, namely the combination of qualitative and quantitative methods. A quantitative method was performed by using a test and a qualitative employed was conducted by using questionnaires and an interview. The collected data were analyzed using a t-test. The results of t-test indicate the sig. (2-tailed) of independent samples t-test of pretest is 0.145 (p>0.05). Thus, it is not significant. It implies the two classes are homogeneous in term of student achievement test. The data analysis of independent sample-test of post-test the sig. (2-tailed) is 0.00 (p<0.05), therefore, is significant. It implies the student achievement tests of two classes are difference after the implementation of RBL. It shows that the students’ achievement results in the experimental class are better than the control class. The implementation of RBL is proven effective in improving students’ learning achievement and students’ creative thinking skill.

1. Introduction
Learning model used in the learning process is one of the determinants of the teaching-learning process in a college. Thus, a study program as the management for education activities should develop resources effectively and efficiently in order to reach the objectives and goals and should be ready to identify the circumstances for the improvement of the college.

Students in college have already been through a long and formal education from the primary school in which the learning was teacher center. However, in college, teachers are supposed to be more creative and innovative, students are considered adults, thus, they are not the learning objects but learning subjects, so that the learning process should be creative, pleasant, and motivating the students and respecting their opinions. The result of the study states that students’ difficulties and failures are because of internal and external factors including students, facility, curriculum, learning sources, and teachers’ abilities in making students learn [5]. To overcome that, the researcher was encouraged to
conduct research-based learning. Considering that adults like practicing and problem-centered learning, learning that integrates new information with their experience, and learning that shows individual attention. Thus, research-based learning is supposed to help teachers and students to be more interested in practicing and following the given subjects and to be more useful for the study program.

### Table 1. Stage of the process of creative skills [11]

| Aspects            | Indicators                                                                 |
|--------------------|-----------------------------------------------------------------------------|
| 1. Preparation     | a. Imagine the meaning of the test                                         |
|                    | b. Understand the test                                                      |
|                    | c. Understand the graph that is almost the same as the test                |
|                    | d. Understand the concept dominating set                                   |
| 2. Illumination and incubation | a. Determine and create a new graph that is different from the others |
|                    | b. Determine the labeling and cardinality of the graph found               |
|                    | c. Expanse the graph found                                                 |
|                    | d. Determine the formula on the graph                                       |
| 3. Evaluating      | a. Check again and determine the cardinality graph                         |
|                    | b. Recheck whether the dominating set formulas have been found right or wrong |

In this stage, students should be more involved in learning (student-center learning). Teachers are the facilitators.

![Figure 1. The Flow Chart the research-based learning [2]](image)

The syntax *Research Based Learning* model consists of three stages: Exposure stage, Experience stage, Capstone stage [1]. Exposure stage is gathering information based on inquiry and looking for the literature on a focused topic. Experience stage is identifying and formulating problems based on a literature study and experimental experience. Capstone stage is explaining a certain plan or idea in giving problem solution or measurement method or computation.

Combining the two RBL models, proposed by Dafik, the researchers mixed in dealing with rainbow connection problems [10]. *First, Gathering information about problems and looking for its literature.. Second, students are encouraged to identify problems to develop problem solving*
strategies based on experimental experience and literature studies. Third, the students were encouraged to identify side coloring on the graph and begin to generalize based on each graph. Fourth, students complete the entire rainbow connection process to produce the rainbow connection number. Fifth, the students write an RBL report supervised by the research group members.

The purpose of this research was to know the effectiveness of research-based learning model compared to a conventional model. In this research, students were asked to locate new patterns of two-dimensional arithmetic. Meanwhile, another class was also taught by the same lecturer but using conventional learning. Dominating set is a concept of a point on the graph with the point as dominating set reach point that is around it and least possible harm. Cardinality smallest dominating set called domination number denoted by \( \gamma = (G) \), dominating set \( D \) with \( |D| = \gamma (G) \), called dominating the minimum. The high end of domination number is how many points in the graph. When at least one point needed to set of dominance in the graph, then \( 1 \leq \gamma (G) \leq n \) for each graph order \( n \). The value of domination number always \( \gamma (G) \leq |V(G)| \).

### Table 2. Indicators of Creative Thinking Skill

| Aspect (fluency) | Indicators |
|------------------|------------|
| Generate lots of answers and of true value |

| Aspect (flexibility) | Indicators |
|----------------------|------------|
| Able to produce various kinds of ideas with different approaches |

| Aspect (originality) | Indicators |
|---------------------|------------|
| Providing unusual answers, others from others, which are rarely given by many people |

| Aspect (elaboration) | Indicators |
|---------------------|------------|
| Develop, add, enrich an idea |

In this study, indicators in determining students’ creative thinking abilities were only assessed through 3 aspects, namely (fluency), (flexibility), and (originality) and the indicator can be seen in Table 3 below. The intended level is in accordance with the work produced by the students. Therefore, in this study, the levels of Creative Thinking Ability (TKBK) of students are described in the following table.

### Table 3. Level of Creative Thinking Ability

| TKBK | Indicators |
|------|------------|
| Level 0 (not creative) | Students are not able to show the three aspects of problem solving |
| Level 1 (less creative) | Students are only able to show fluency in solving problems |
| Level 2 (creative enough) | Students are able to show novelty or flexibility in problem solving |
| Level 3 (creative) | Students are able to demonstrate fluency and novelty or fluency and flexibility in problem solving |
| Level 4 (very creative) | Learners are able to demonstrate fluency, flexibility, and novelty and flexibility in problem solving |

2. Research Method

This study was triangulation research using mix methods of qualitative and quantitative. The quantitative method was performed through test while the qualitative method was performed through questionnaires and interview. The variables were learning model as an independent variable and two-
dimensional arithmetic of achievement students as a dependent variable. The design of this study was an experimental design with the main characteristics in which the samples used in experiment or control group were taken randomly from a certain population with Pretest-posttest only Control Design.

\[
\begin{array}{ccc}
R & O1 & x & O2 \\
R & O3 & - & O4 \\
\end{array}
\]

Sugiono (2017:212)

- \( R \) = Experimental and control group were taken randomly
- \( O1 \) & \( O3 \) = The two groups were initially observed using pretest to identify the early ability. The early ability was supposed to be the same
- \( O2 \) = Post-test result in experimental class
- \( O4 \) = Post-test result in control class

In this design, there were two randomly-taken groups. The first group was given a treatment (X) and another group was not. The group given the treatment was experimental class and another group was a control class. The effect of the treatment was \( (O1 : O2) \), in a true experiment, the effect of a treatment was analyzed using t-test [9]. Figure 1 showed the triangulation method in which the qualitative data were triangulated with the quantitative data to identify the effect of the research-based learning on the material of dominating set.

**Figure 2.** The model of the Triangulation method
2.1. Population
The population of this research was 4-year students at the University of Jember 2 in the academic year 2017 / 2018. The sampling technique used was clusters of random sampling done by picking 2 class at random, a class experiment with 30 students applying an RBL model, and one class control applying conventional 30 students with learning model. Data collection was conducted in February - April 2018. The research instruments used were the test and an observation. To collect the data of learning achievements, writer used instruments of essay question streak to find new patterns and be able to generalize common form taken from the discrete mathematics. The observation sheets were used to see the plan which has been made.

2.2. Instruments
The instruments used in this study were tests, interview, and observation. Population employed national curriculum Indonesia by linking worksheets students. For grades, a survey experiment with 10 questions was used. With scales totally agree (score) 5, agree (score) 4, Doubtful (score) 3, disagree (score) 2, strongly disagree (score) 1. A testing instrument has been validated by a math professor at the University of Jember.

2.3. Task
This research provides the following calculation the task of participants: to measure the student ability rate, it takes measuring instrument in accordance with an indicator to be measured. Researchers constructed up a new and different test from the previous ones. The test instruments used was related to determining the dominating set on graph. For more information see the table below.

![Figure 3. The example of the dominating set](image)

\[ D = [X_1, A] \]

Students gave symbols at any point and sides on the graph, and then determined the value of Cardinality and dominating set, and when it is expanded and n was added.

2.4. The data collection and analysis
Experimental and control classes generated pretest and posttest data. A quantitative analysis used an SPSS software version 20. Qualitative data employed scale intervals in the research and interviewing students. Descriptive statistics and inferential were used to analyzed data quantitative and qualitative. The information obtained from the data was the frequency of the mean, and standard deviations were used to describe the statistics. In addition, a t-test sample was employed in the hypotheses inferential to obtain the impact of RBL between experimental and control classes [3]. Independent t-test sed for sample comparison between the average score second group which have made a significant difference at the level of 0.05 percentage point

3. Research findings
The research findings revealed that the impact was effective for the implementation of RBL learning. Independent t-test was used in sample analysis t-test to obtain the value of a test and post pretest the average score class experimentation and control class, and the results of normality. The number of respondents as a whole consisted of 60 students.
Figure 4. The distribution of student creative skills in the experiment class

Pretest experiment class results as seen in Figure 4 show students’ creative abilities Level 0 (not creative) is 17%, Level 1 (less creative) is 23%, Level 2 (creative enough) 23%, Level 3 (creative) is 20%, and Level 4 (very creative) is 17%.

Figure 5. The distribution of student creative skills in the control class

Pretest control class results in Figure 5 show students’ creative abilities Level 0 (not creative) is 20%, Level 1 (less creative) is 23%, Level 2 (creative enough) 20%, Level 3 (creative) is 20%, and Level 4 (very creative) is 17%. From the study results, it was found the effective findings of the use of independent sample t-test on research-based learning using t-test analysis was obtained through the mean scores of pretest and post-test in experimental class and control class, and normality test was conducted. The respondents were 75 students.

Table 4. Test the homogeneity of pretest two classes

| Test of Homogeneity of Variances |
|---------------------------------|
| Class                           |
| Levene Statistic                | df1 | df2 | Sig. |
| 1.793                           | 1   | 58  | .186 |

Table 4. The results of the homogeneity test of the pretest, the value (Sig.) in the Test of Homogeneity Variances table is 0.176 so it can be concluded that the assumption of homogeneity of
variance is fulfilled. It is because the significance value obtained is more than 0.05, the data has the same or homogeneous variance.

Table 5. Comparison value pre test scores average class experiment and class use sample control independent t-test.

| Data Pretest | Class          | N  | Mean ± SD | T  | Df  | Sig(2-tailed) |
|--------------|----------------|----|-----------|----|-----|---------------|
|              | Experiment     | 30 | 63.1000   | 1.478 | 58  | .145          |
|              | Control        | 30 | 61.8667   | 1.478 | 55.698 | .145          |

This shows the results of pretest class control and class significant experiment that is shown in Table 5. The results of the trends pretest was 0.05 percentage point in the creation and post a test 0.00, the average value of control to that class of 61.8667 (sd = 2.88556), while in the case of a class experiment obtained the mean value of the 63.1000 (sd = 3.54625) the difference with off-field pretest class control and a class experiment the score 2 groups [t (60) = 1.476, p > 0.05], not significant. Table 5 shows that the results of the t-test a sig value.(2-tailed) of its yield pretest independent t-test is 0.145 (p > 0.05). This result shows that is not significant. This means that these two classes show homogeneous. This indicates that the results of the to study for students from the two groups is as the likeness of at the beginning of this research.

Table 6. The results of posttest, its mean value between class control and a class experiment Group Statistics

| Data _Post-test | Class          | N  | Mean ± SD | Std. Error Mean |
|-----------------|----------------|----|-----------|-----------------|
| Experiment      | 30             | 80.1667 | 3.31229   | .60474          |
| Control         | 30             | 65.9333 | 2.27328   | .41504          |

Table 6 shows the results of control class’ posttest score is 65.9333 (sd = 2.27328) for the class experiment 80.1667 (sd = 3.31229). There is a difference in between the two posttest the average significant t (60) = -19.406, p & it is; 0.05 percentage point of this result indicates that it is significantly different between experimental and control class.
Table 7. Test the normality of both class from the post test

| One-Sample Kolmogorov-Smirnov Test | Posttest (Control Class) | Posttest (Eksperiment Class) |
|-----------------------------------|---------------------------|-----------------------------|
| N                                 | 30                        | 30                          |
| Normal Parameters<sup>a,b</sup>   |                           |                             |
| Mean                              | 65.9333                   | 80.1667                     |
| Std. Deviation                    | 2.27328                   | 3.31229                     |
| Most Extreme Differences          |                           |                             |
| Absolute                          | .339                      | .227                        |
| Positive                          | .229                      | .189                        |
| Negative                          | -.211                     | -.227                       |
| Kolmogorov-Smirnov Z              | 1.108                     | 1.195                       |
| Asymp. Sig. (2-tailed)            | .125                      | .082                        |

<sup>a</sup> Test distribution is Normal.
<sup>b</sup> Calculated from data.

Table 7. The results of testing the normality of each group obtained a significance value of each, namely the post-test (control) of 0.125, post -test (experiment) of 0.082. The significance value of the two classes is greater than the value of $\alpha$ (0.05), meaning that the two classes of research samples are normally distributed.

Table 8. comparison value posttest the average score class experimentation and class control use independent sample t-test

| Independent Samples Test | Class | N | SD | T | Df  | Sig(2- tailed) |
|--------------------------|-------|---|----|---|-----|----------------|
|                          | Experi| 3 | 14.2 | - | 58  |     .000       |
|                          | Control| 3 | 11.2 | - | 51.3|     .000       |

Table 8 that the results sig t-test value.(2-tailed) from the post-test independent t-test is 0.000 (p & it; 0.05), this result indicates that significant which means that second class showing no significant differences the students after he received an RBL implementation.

Figure 6. The distribution of student creative skills in the control class
Posttest control class results show students' creative abilities Level 0 (not creative) is 17%, Level 1 (less creative) is 20%, Level 2 (creative enough) 23%, Level 3 (creative) is 23%, and Level 4 (very creative) is 17%.

Posttest Experiment class results show students' creative abilities Level 0 (not creative) is 5%, Level 1 (less creative) is 5%, Level 2 (creative enough) 15%, Level 3 (creative) is 25%, and Level 4 (very creative) is 50%.

Based on Figure 4 it was stated that the highest criteria value achieved is 43% and 17% in the medium category, and there are obtained 7% of the inferior scoring. From the data be concluded that RBL learning can work well because there were only two students. It was given to them after the implementation of such RBL applied learning, to explore their level of understanding students. For the control class, it was not taught using a conventional learning. Data analysis revealed that students became competent in manipulating in a variety of the concept of dominating set. Competence has really allowed us to believe that they naturally could use the operators to make the new graph as distinct from they have ever come. However, the interview has enlightened because we observed that a lot of students who have difficulties in making competent graph new so find new the formula of dominating set.
When we expand the above dominating set, we have found the following dominating set.

\[
D = \{x^1; y^1\}
\]

It is shown that \(n \in \text{even}, n \in \text{odd}\). Assumed that \(\gamma(L(V_u)) < \frac{n}{2}\). Selected set of dominator points (V-D) the members showed different results. Whereas to see the results of the contradiction from the determination of the D point other than dominator V-D, even though slices between the set of neighboring points from members V-D with D can be seen, is a dominator point does not dominate several points. Therefore, it can be concluded that by making the above \(\gamma(L(D_f_n)) < \frac{n}{2}\) did not meet the requirements of the set of location domination and contradictions Therefore, the location dominance number of the Wheel graph \(\gamma(L(D_f_n)) \geq \frac{n}{2}\)

As an illustration, an example of the set of domination locations of graphs that do not meet the requirements of the dominant set is given. Next, it is shown the upper limit of the number of domination of the location of the Double Fan graph is \(\gamma(L(D_f_n)) \leq \frac{n}{2}\), to take the set of location domination that. \(D = \{x^i, 1 \leq i \leq n\}\) is to get a different slice \(N(u) \cap D \neq N(v) \cap D \neq \emptyset\) so that it meets the requirements of the location domination set. Therefore, the upper limit of the number of domination of Double Fan graph is \(\gamma(L(D_f_n)) < \frac{n}{2}\). So it was concluded that \(\gamma(L(D_f_n)) < \frac{n}{2}\).

To know perception students on the implementation of the research fee-based learning, the researchers conducted interviews with students and teachers. In order to overcome ethical problems, the anonymity of lecturers and students are preserved from the data and keeping the votes, they are identified as a teacher in the following report. The data obtained from the interview are discussed below:

Quotations interview

Researcher: Is there any information that can be obtained after working on the problem?
Student: I can make a new graph and can determine the cardinality, sir.
Researcher: How do you work on the problem?
Student: Make a simple graph first, add a new pack or add it to the extension
Researcher: Is there anything you can't do with the steps?
Student: Basically the same as defining a graph that is exemplified and taught, only we are required to be observant and careful in determining the cardinality and the dominating set formula on the new graph
Researcher: In the post test problem, what difficulties did you encounter in working on the problem?
Student: I still can’t determine with the cardinality and the new graph dominating formula that I made, so I still ask friends who can and better understand.

Figure 10. Phase Portrait Student with Low Creative Skill of Student S1

Figure 11. Phase Portrait Student with Moderate Creative Skill of Student S2

Figure 12. Phase Portrait Student with High Creative Skill of Student S3

Figure 13. Phase portrait combine
4. Discussion
This research was conducted to analyze the implementation of research-based learning (RBL) on students' creative skills. The findings of this study indicate that the implementation of research-based learning has a significant influence on the creative skills of students in the experimental class. The students in the experimental class showed their creative skills in mathematics compared to the control class. The results showed that the improvement of learning outcomes and students' creative skills were seen in the post-test. The experimental class value is significantly better because it is supported by the RBL learning to improve students' creative skills. Students in the experimental class apply RBL learning, where they have an understanding of the concept to help each other, therefore RBL learning is very good for improving student creative skills. This is consistent with Sutarto's process of generalizing research is a pattern the number of [11]. Sota & Peltzer reported that the implementation of an RBL among all these students a degree of master with a task for research in search of journals and read, analyze, synthesis, present, and discuss together able to improve cognitive ability, knowledge, ethics, skill, social, communication, arithmetic, and information technology skills, and satisfaction in to seek information is at a high degree [8].
RBL learning can fully be recommended for education technique to produce higher students' motivation and able to improve learning outcomes high and aspects of life that develops with both [4]. Alacapina said that the outcomes cognitive average of a group based in which RBL techniques used, found significantly higher than average for another group. Based on this, can be stressed that the engineering project effective in achieving results in cognitive. Next, the research must be based on RBL learning applied in a number of to expand research in the study in all institutions, and for implements research in education, the relationship between research and teaching [7]. When RBL learning was applied in the class, according to observation researchers, the students were more creative, active, and think more critically than students in conventional learning applied in the control class. By giving a fun atmosphere for students, it can together over learning. This is in accordance with research by Marian stating learning based an RBL actually learned in action learning based an RBL. This involving students so that they no longer a container information in passive, but a pursuer active knowledge. Classrooms innovative break up the wall boredom and apathetic. They were involved and motivate students to take part actively in themselves. Students became a collaboration members of teachings, share, and learning. They are constructor of knowledge, and collaborator building an understanding. The purpose of learning a new model changes the relationship between assessment and instructions students. In conventional class tend to be passive and they are less driven to explore their potential. Students in conventional class tend to be passive and less driven to explore their potential.

5. Conclusion
The research results and the hypothesis proved that research-based learning model is more effective to improve student achievement than the conventional model. However, the research-based learning in this research was done in a very limited time so it is not as good as those if with the appropriate time with material characteristics in research. In dominating, the learning with research-based learning is more effective than conventional learning. Therefore, research-based learning is the most appropriate as an alternative for discrete mathematics lecturers, especially in the dominant set material.

Acknowledgment
The author would like to express a sincere gratitude to the supervisors and lecturers of discrete subjects at the University of Jember to conduct this research study and to the Dean of the Faculty of Teacher Training and Education, Jember University, Indonesia, who has given the support to conduct the research.
References
[1] Arifin P 2010 Paper Seminar Nasional Research-based Learning. Bandung: Bandung Institute of Technology
[2] Dafik 2018. Development of PBR (Research-Based Learning) in the course. Impact of PBR in Unej Environment. Jember: University of Jember
[3] Hilton P R, Brownlow C, Mc Murray I, Cozens B 2004 SPSS explained. Routledge Inc, New York
[4] Nadine et al 2015 Die Lernfabrik- Research Based Learning for Sustainable production Engineering. Procedia CIRP 126-131
[5] Suci N M 2008 Implementation of Problem Based Learning Model to Increase Student Learning Participation and Learning Student Accounting Department of Economics Undiksha. Journal of Educational Research and Development 2174-86
[6] Sutarto et al 2018 J. Phys.: Conf. Ser. 1008012060 1-8
[7] Schapper J and Mayson E S, 2010 Research-led teaching: moving from a fractured engagement to a marriage of convenience. Higher Education Research & Development 29 641-651
[8] Sota, Chulaporn and Karl P 2016 The effectiveness of Research-based Learning among Master degree Student for Promotion and Preventable Disease, Faculty of Public Health, Khon Kaen University, Thailand. International Conference on intercultural Education “Education, Health and ICT for a Transcultural Word;”, EDUHEM
[9] Sugiono 2017 Quantitative, Qualitative, and R & D research methods Bandung: ALFABETA
[10] Suntusia, Dafik, & Hobri 2019 The Effectiveness of Research Based Learning in Improving Students’ Achievement in Solving Two-Dimensional Arithmetic Sequence Problem. International Journal of Instruction 12 1
[11] Wallas, 1988, Chemical Process Equipment Selection and Design, 3rd editions, Butterworth, USA.