

The Analysis of Creative and Innovative Thinking Skills of the 21st Century Students in Solving the Problems of “Locating Dominating Set” in Research Based Learning

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Abstract—In the 21st century, creative and innovative thinking skill is greatly required. According to the P21 platform (Partnership for 21st century learning), someone will survive in the 21st century if they have the skills of creative and innovative skills. This study applies Research Based Learning (RBL), in which the level of the students' creative and innovative skills in class will be seen. The application of Research Based Learning (RBL) is done to the 34 students in the modeling class working on the problem of Locating Dominating Set. The data of his study was analyzed qualitatively to determine the level of creative and innovative thinking skills. Based on the result of the research, the level of the students' creative and innovative thinking skill is as follows: Out of 34 students, 3 students were chosen to represent critical thinking skill at level 4, 3, and 2. Each students has different character in accomplishing the A, B, and C test. Also, among those 3 students, the test result was analyzed during 3 meetings. The result showed that there was no students got 0 score of the critical thinking test. It means that the students master creative and innovative thinking skills in solving the problem, particularly in solving locating dominating set.

Keywords— Creative and innovative thinking skills, Research Based Learning, Locating Dominating Set.

I. INTRODUCTION

Mathematics learning is greatly needed by the students. The quality of Mathematics education in Indonesia is relatively low compared with other countries. To overcome these problems, educators should create a fun learning for the students, so that there are aptitude and interests of students towards Mathematics. In this new era, often referred to by the 21st century learning, the development of the 21st century is marked by the use of information and communication technologies in all aspects of life, including in the learning process, both from the aspect of education at schools, universities, as

well as in work place. The ability to think critically, solve problems and collaborate become an important competency in entering the life of this century. One lesson that might be done is Learners-centered learning, which is different to the traditional way of teachers-centered learning, in the sense that they both have different approaches to the content, instruction, classroom environment, assessment, and technology (Ekawati, 2011: 2).

Rotherdam & Willingham (2009) explain that the Partnership for 21st Century Skills demand everybody to master the 21st century skills that cover creative and innovative thinking skills, critical thinking skills, communication skills and collaboration skills, or it is called as the 4Cs. Meanwhile, according to the National Education Association to succeed and compete in the global community, students must be proficient and have the skills as communicators, creators, critical thinkers and collaborators (Assyaibani, 2016).

One of the aspects which are examined in this study is the level of creative and innovative students in solving a problem about locating dominating set. According to Guilford in Satiadarma (2003: 111), creative thinking is the thinking process spread (divergent) with an emphasis on diversity in terms of the number and suitability. Working in a creative idea to make something real and useful into a study where innovation will occur (Anonymous, 2015: 3).

Based on the previous background, there is a need for a specific research about the readiness of educators to face the 21st century education era. Thus, the researchers applied research based learning as a reference in learning process. The results of the research conducted by Assyaibani (2017: 19) has found out that the purpose of the Research Based Learning is to help students develop the intellectual abilities and a strong practical connection between the limits of its own research and student learning. Further, the aim of this research is to analyze

the ability of creative and innovative thinking skills students in solving the problem of locating dominating set by using research-based learning that lead to learning in 21st century, and later, students are able to think independently, and able to build up inspiration and ideas without the help of others.

One model of learning that can support and train the creative and innovative thinking skills of students is Research Based Learning (RBL) learning model. According to Dafik (2015), RBL is a learning method that uses contextual learning, authentic learning, problem-solving, cooperative learning, hands-on and minds on learning and inquiry discovery approach. Meanwhile, according Khamdit, RBL is a learning approach that emphasizes learning by practice, learn from real situations, produce something of the process of thinking, to work systematically, forming the individual's knowledge, using the research process to solve problems, generate response of doubts and analyze their data own (Assyaibani, 2016: 4).

SuchadaPoonpan (2001) states that (RBL) provides an opportunity or an opportunity for learners to search for information, draw up a hypothesis, collect data, analyze data, and make conclusions on data that has been arranged. RBL is a learning system that involves authentic problem solving with the viewpoint of the formulation of the problem and solve the problem, followed by communicating the benefits of the research results (Chamdani, 2015: 674).

The target of the application of RBL is encouraging the creation of high-level thinking skills in lecturers and students. Students are not only provided with information and knowledge, but they also must be encouraged to achieve a higher level, creating or communicating. Achievements to this level in learning theory are known as the achievement of higher level thinking skills translated from the sentences indicating Higher Order Thinking Skills (HOTS) (Dafik, 2015).

Lots of studies in learning, as well as discrete modeling studies, are available these days. Discrete modeling can be used to train students' creative thinking skills as they relate to the real world that can be solved in the right way according to the teaching of discrete modeling. Discrete modeling studies newly developed are pertinent to locating studies Dominating set, particularly dealing with locating Dominating set. We studied the development of dominating set. Dominating set is a concept of determining a point on the graph with the provisions dominating set point as to reach a point in the surrounding areas and to a minimum. The cardinality of the smallest of the so-called domination Dominating set number is represented by $\gamma(G)$. Dominating set D with $|D| = \gamma(G)$ minimum is called Dominating set. The upper

limit of the domination number is the number of points on a graph. When at least one point is needed to set domination in the graph, then $1 \leq \gamma(G) \leq n$ for each graph is air-order n . Value of domination number is always $\gamma(G) \leq |V(G)|$ (Haynes et al, 2002). While locating Dominating set is a graph $G = (V, E)$, which is said to be met if the set point locations domination dominator D qualify any different points outside D namely $V - D$ have different slices with D . For example, V set point and E set edge of the graph G , so that $\{u, v, \in V \setminus D\}$ then apply: $N(u) \cap D \neq \emptyset$ and $N(v) \cap D \neq \emptyset$, $2) u \neq v$ then $N(u) \cap D \neq N(v) \cap D$ (Honkala, 2002: 35).

In this study, there are three indicators to measure creative and innovative thinking skills of students, i.e. Think creatively, Work creatively with others, and implement innovation. The following criteria of three indicators are operative, according to anonymous, 2015. (1) Thinking creatively based on certain criteria, a) Ability to generate creative ideas such as arguments, b) creating something new both ordinary and extraordinary concept, c) collaborating their ideas for improving the creative output. (2) Working creatively with others based on certain criteria, a) Developing and implementing as well as communicating new ideas to others, b) working intensively in the group and were able to provide input into the work, c) Opening and responding to something new and different. (3) performing implementation and innovation with the following criteria, *inter alia*, a) Working in a creative idea to make something real and useful into a study where innovation will occur, b) producing something new, c) being able to work with my own results. Of each indicator criteria above, if the student is able to complete any of the aforementioned indicator properly, then it will get a score of 5 for each criteria.

Having obtained a score for each question for all students according to pre-determined indicators, the total score for each student was achieved. The score can be measured by the level of creative and innovative thinking ability as follows.

Creative Thinking skills level

Critical Thinking Skill Level	Score
Level 0 (Not Creative)	0-72
Level 1 (Hardly Creative)	72-144
Level 2 (Fairly Creative)	144-216
Level 3 (Creative)	216-288
Level 4 (Very Creative)	288-360

II. METHOD

The research method used in this research was descriptive qualitative method, because this study grappled with assessing and analyzing students' ability to solve problems that arose through the RBL. The population in

this study were all 6th-semester students who took a course in modeling. There were 34 people involved.

The steps in this study were divided into three stages, namely preparation phase, the implementation phase, and the final stage of the study. **The preparation stage** involves the establishment of a research group consisting of researchers / lecturers with expertise in the areas that will be studied, developing the syllabus, one-semester lesson plan, RTM (worksheet), MFI, and course outline to implement RBL in learning. **The implementation stage** covers the implementation and administration of the learning process in RBL, Research Activity Test (TAR). These stages include (1) providing basic information about the material being studied, (2) showing the results of the research faculty in the study group or research group concerning the material being discussed, and (3) dividing the students in discussion

groups, (4) distributing the assignment to students in the form of discussion groups on (a) the substance of the research, (b) the research process, (c) method of analysis, (d) formulation of conclusions, and (e) values that emerge from the research results (4) to faculty-led discussions among groups of students, (5) drawing conclusion under lecturer's guidance. At this stage the students were more engaged in learning. Lecturer act more as a facilitator. Where possible, during these discussions, if there are some problems that need literature, lecturers can support the students to gain required information through online media (internet) so that the problems faced by students can be missed. **The final stage**, which was related to doing the data processing, data analysis and drawing conclusion.

The steps in this research can be described in the following flowchart:

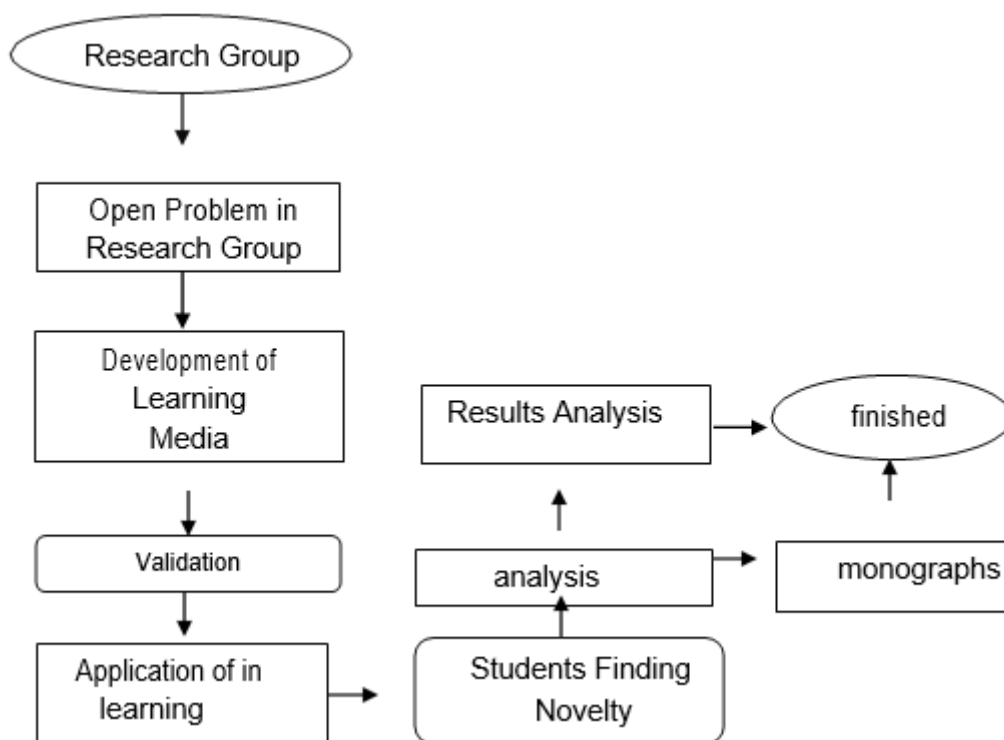


Fig. Flowchart lines of inquiry

In this study, the measured data were related to creative and innovative thinking ability of students accrued through the activities of Research Activities test the ability of students to construct a new graph that had not been studied previously in research locating determination Dominating set. The results of the TAR were then collected and analyzed for creative and innovative thinking skills of students based on three indicators: think creatively, work creatively with others, and implement innovation. Then the students' level of creative and innovative thinking skills were determined based on completeness of these indicators to see scores of

CTT/TBK (Creative Thinking Technique).

III. RESULTS AND DISCUSSION

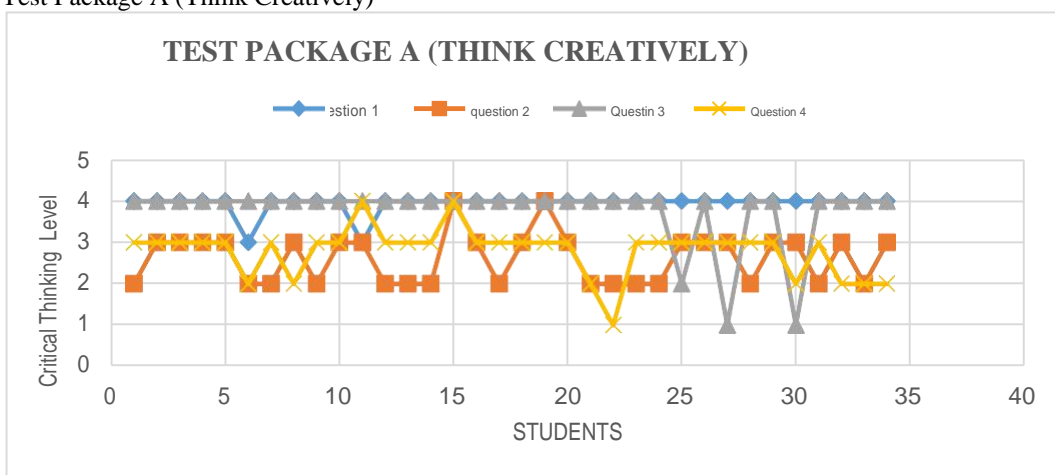
Initial activity in this research was to conduct research of planning in a research group, developing the required instructional instruments, planning the best possible learning implementation and indicators of what is needed to analyze the creative and innovative thinking skills of students of the test results in research activity. After planning, the researchers developed instructional instrument needed in research and the instruments were then validated by experts. The instruments included

validation results, the Student Worksheet and learning achievement test. Results of the validation of instructional instruments in this study were obtained on the mean value so that these results showed that the instructional instruments can be used in research. Once validation was done, the instructional instrument were for use, then the researchers carried out research in the classroom. The research was carried out four times of the meeting, where the first to the third meeting was meant to introduce the concept and flow of research in graph theory about locating Dominating set. Activities of researchers in managing class and activity of students in the class were rated by the observer, which aimed to determine the learning process. Both teacher's activities and activities of students in the class were observed and rated. Implementation of learning through RBL method

1. Test Package A (Think Creatively)

aimed to introduce the concept of Locating Dominating set as the research problem. After the introduction and explanation of the concept related to Locating Dominating set through learning RBL, then at the end of the learning, test was done. With this, students were expected to be able to generate new findings in the form of Determination Locating Dominating set that has never been studied before. Test results of research activities were undertaken by students and then analyzed to determine the students' level of creative and innovative thinking skills. Creative and innovative thinking skills of students were measured by three indicators aforementioned.

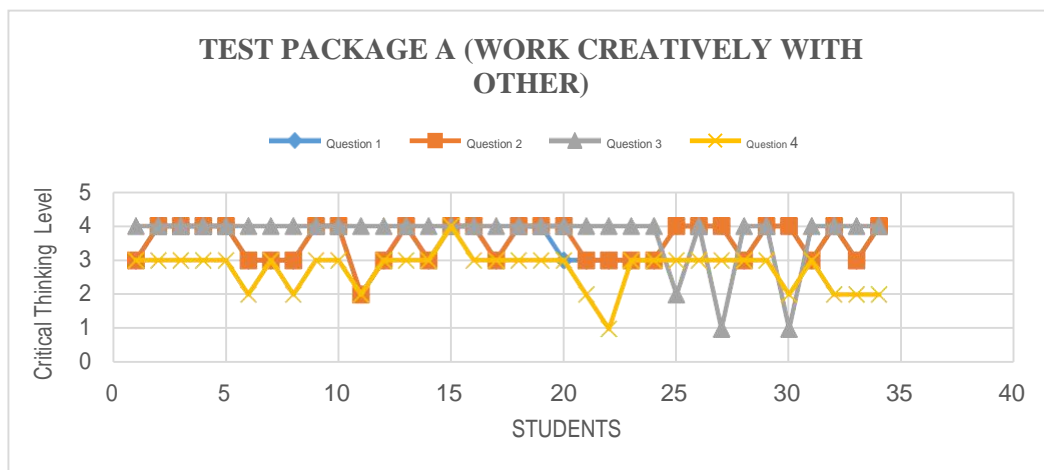
The following is the diagram of the students' test result score of Package A Test, Package B Test, Package C Test, with four (4) questions for each test.



Judging from the diagram above, for Question 1 there were 32 students who received a score of 4, and 2 student achieved a score of 3. The diagram clearly shows that the students are able to solve problem number 1. For question number 2, there were two student who achieved a score of 4. 17 student gained a score of 3, and 15 students obtained a score of 2. This meant that the students were creative and fairly creative in solving question number 2. For question 3, there were 30 students achieving a score of 4.

2. Test Package A (Work Creatively with Others)

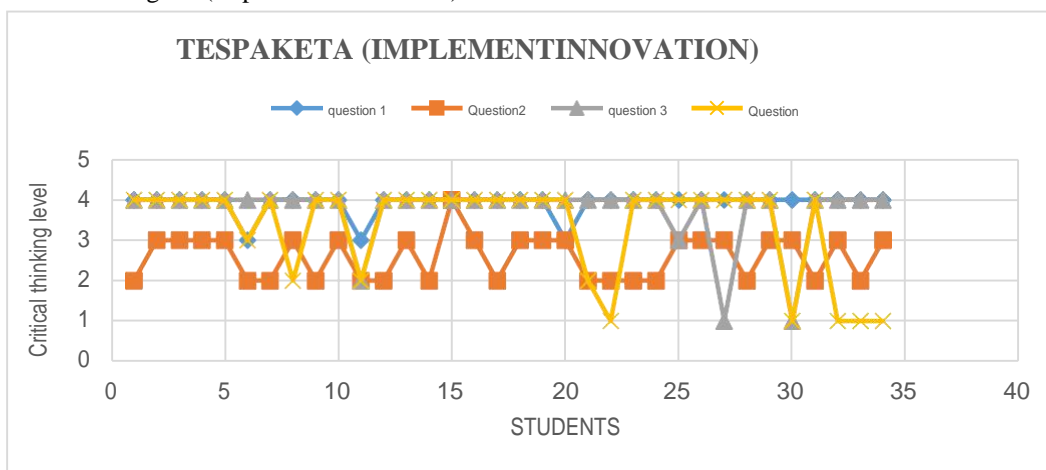
of 4. 2 students achieved score of 2 and 1. These results clearly indicated that the students were very creative, creative enough and there was indication of being hardly creative in solving number 3. On question number 4, 1 student achieved a score of 1. These values represent students' critical thinking levels, be it very creative, creative, fairly creative, or hardly creative in solving number 4, but most of them were creative students in solving the problem.



From the above diagram, 18 students obtained a score of 4. 15 students were at a score of 3, and 1 student was at a score of 2. As regard with question 1, students were proven able to complete the questions at very creative, creative and also fairly creative level upon working with others. In terms of question 2, there were 19 students achieved a score of 4, 14 student gained a score of 3 and 1 student gained a score of 2, which meant that students were very creative, creative and also fairly creative when working with others in solving number 2. For question 3, there were 31 students who obtained score of 4, 1 student was at a score of 2, and 2 students obtained a score of 1.

These figures implied that the students were very creative, hardly creative and fairly creative when working with others in solving number 3, but most students were very creative in completing the very question. On question 4, there was one student who got score of 4, 24 students were at a score of 3, 8 students obtained score 2, and 1 student obtained score 1. These inferred that students were at very creative, creative, fairly creative level and hardly creative work when they worked with others in solving the problem number 4, but most were proven creative in solving it.

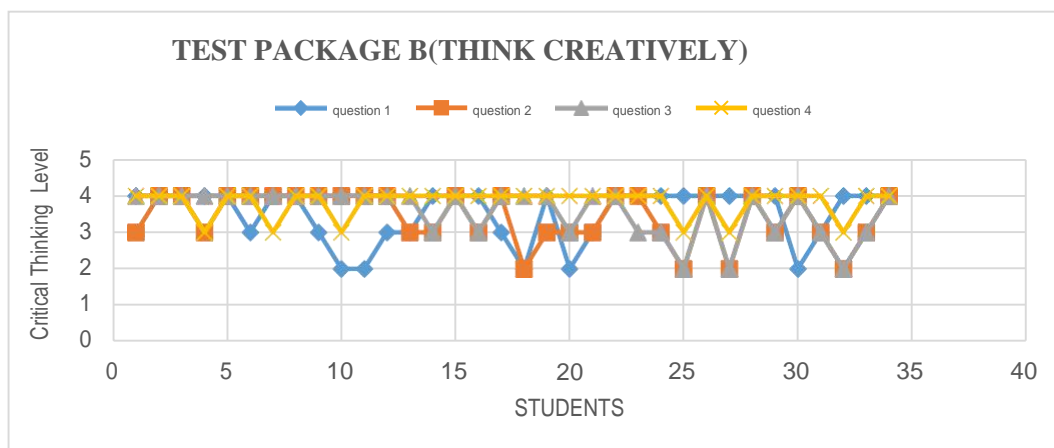
Test Package A (Implement Innovation)



In the diagram above it can be seen that there are 31 students in a score of 4, and 3 students gain a score of 3, meaning that the students are very innovative, and fairly innovative in solving number 1. For Question 2, there is one student at a score of 4, 18 students at a score of 3 and 15 students achieve a score of 2, which means that the students are very innovative, innovative, and fairly innovative in solving number 2, but most of them are innovative upon working on the questions. On question 3, there are 30 students obtaining a score of 4, 1 student achieved a score of 3, 1 student got a score of 2, and 2

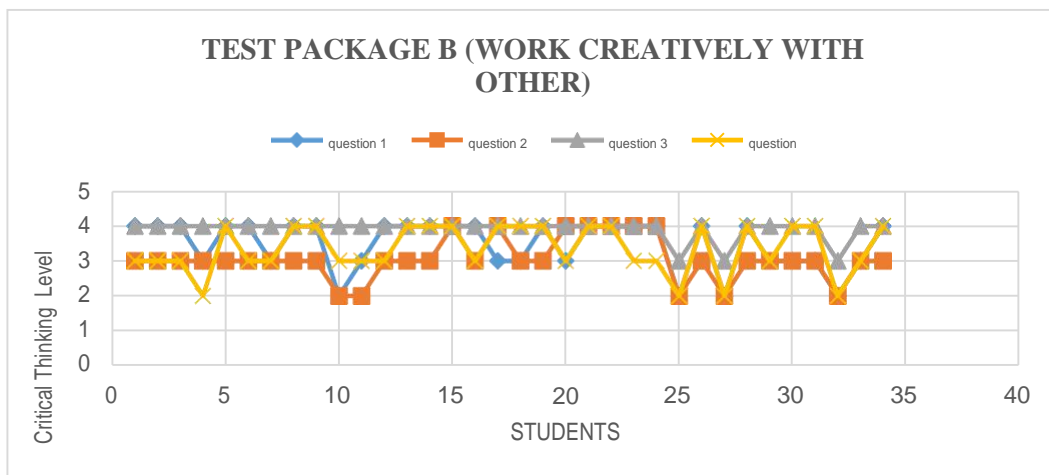
students were at a score of 1, meaning that students are very innovative, innovative, fairly innovative and less innovative in solving number 3, but most students are very innovative. On question 4, there are 25 students at a score of 4, 1 student is at a score of 3, 3 students achieved a score of 2, and 5 students obtained a score of 1, meaning that students were very innovative, innovative, fairly innovative, and hardly innovative in finishing question number 4, but most were very innovative in the finishing.

Test Package B (Think Creatively)



From the diagram above note on Question 1 there are 23 students who get score of 4, 8 students obtain score of 3, and 3 students in get score of 2, which shows that there are students who are very creative, hardly creatively and also fairly creative. However, most scores are very creative students in solving number 1. For question number 2 there are 17 students at a score of 4, 11 students at a score of 3, and 6 students at a score of 2, meaning that there are students who are very creative, creative, and fairly creative in solving problem number 2. On question 3, there are 23 students in a score of 4, 8 students in scores of 8 and 3 students at a score of 3, which means that there are students who are very creative, creative, and fairly creative in solving number 3. As for question number 4, there are 28 students who achieve score 4 and 6 students are at score 3. It means there are students achieving very creative and creative thinking level upon working on question number 4.

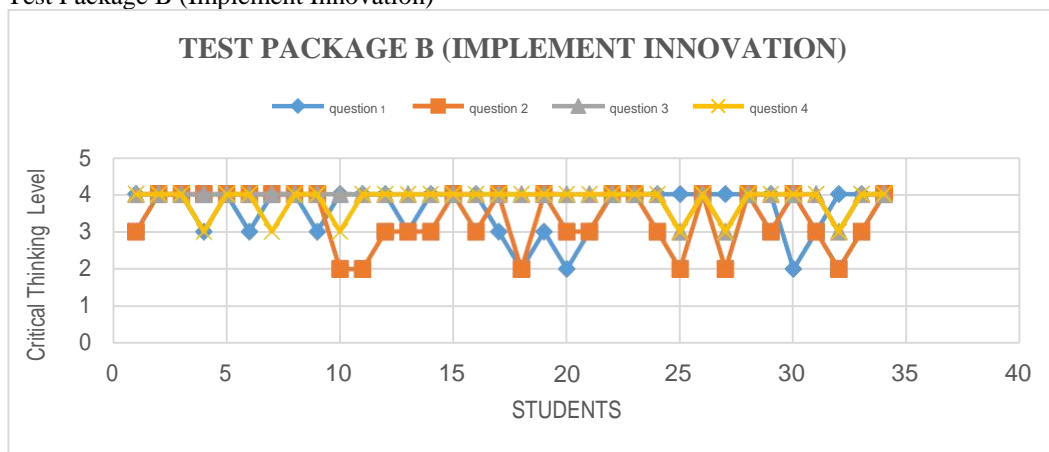
5. Test Package B (Work Creatively With Other



In the diagram above, on question 1, there are 20 students obtaining a score of 4. 10 students achieve a score of 3, and 4 students achieve a score of 2, meaning that the majority of students are very creative when working with the others. On question 2, there are 6 students who obtain a score of 4. 23 students are at a score of 3 and 5 students in a score of 2, it means some of the students work creatively with others in the problem number 2. On

6. Test Package B (Implement Innovation)

question 3, there are 31 students who get a score of 4, 3 students gaining a score of 3, which means students work very creatively with others when working on question number 3. While on question 4, there are 16 students who get a score of 4, 14 students who achieve a score of 3, and 4 students obtaining the score 2. That indicates that students are able to work together with other creative on question 4.

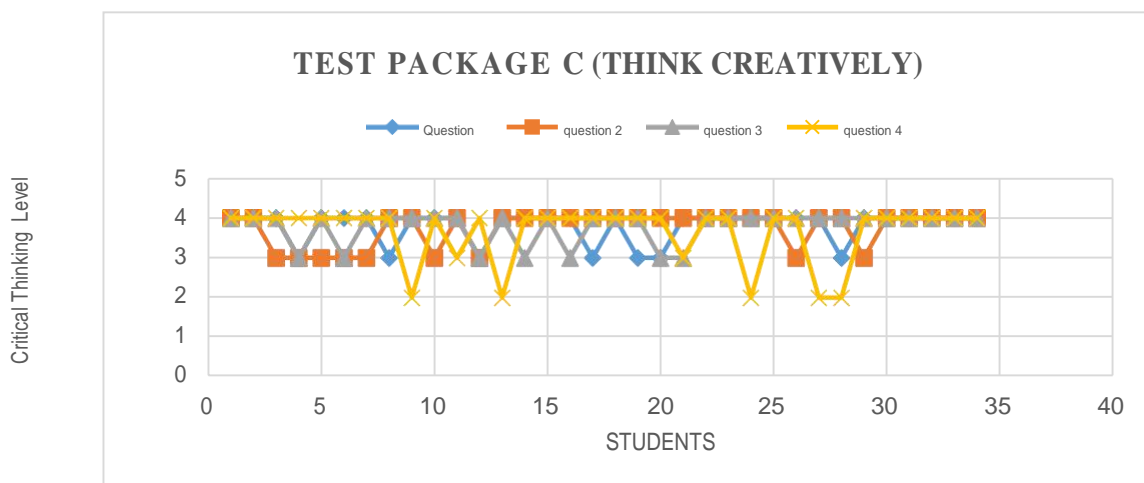


The results of the diagram above shows that there are 23 students who obtain a score of 4 and 8 students who get a score of 3 when working on the problem number 1. This means that the majority of students are very innovative. On Question 2, there are 17 students who gain a score of 4, 11 students who obtain a score of 3, and 6 students who gain a score of 2, so the majority of students are very

innovative on the problem number 2. In question number 3, there are 31 students who obtain a score of 4, and 3 students who gain score 3. It can be seen that the majority of students are very innovative in solving the problem number 3. While in question 4, there are 28 students who get a score of 4 and 6 students who achieve a score of 3, which means that the average students work innovatively

in working on question 4.

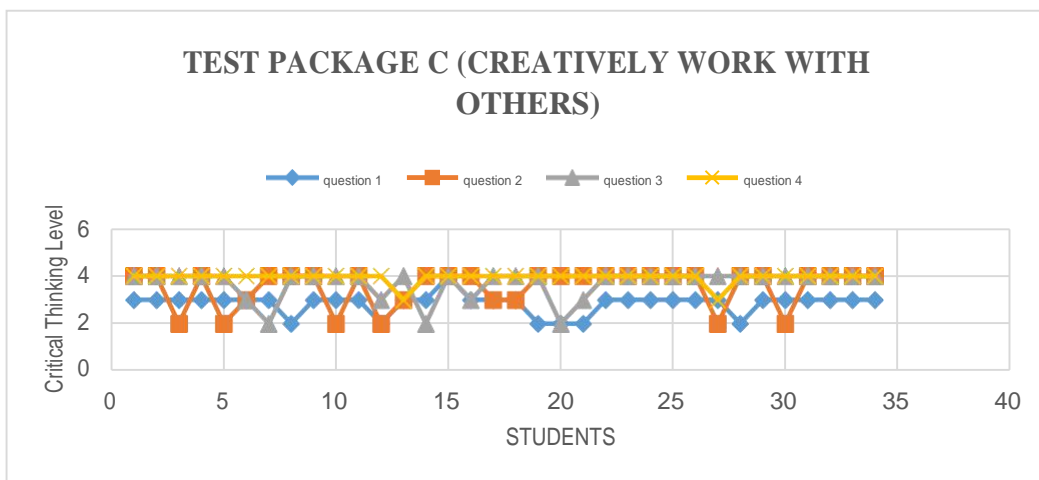
7. Test Package C (Think Creatively)



In the diagram above, there are 27 students who achieve a score of 4, 6 students who obtain a score of 3, and 1 student who gets a score of 2, which means that students are mostly very creative in solving question number 1. For question number 2 and 3, there are 27 students getting score 4, and 7 students achieving a score of 3, 8.

meaning that the students are very creative in solving number 2. As to question 4, there are 26 students who achieve a score of 4, 3 students who get a score of 3, and 5 students who get score 2. This means that the majority of students are very creative in solving problems on Question 4.

8. Test Package C (Work Creatively with Others)



As shown in the diagram above, there is one student who receives a score of 4. 27 students receive a score of 3. 6 students receive a score of 2. This means that most of the students are able to work creatively with others on the problem number 1. For question number 2, there are 24 students who receive a score of 4, 4 students who get a score of 3, and 6 students who gain a score of 2. Most students are at a score of 4, which means that students are very creative in working creatively with others in solving

number 2. On question number 3, there are 27 students who get a score of 4, 4 students who get score of 3, and 3 students who obtain a score of 2. This also includes highly capable students who can work creatively with others in solving question 3. On question 4, there are 32 students who get a score of 4, and 2 students who get a score 3, meaning that students are very capable of working creatively with others in solving number 4.

③ Menentukan Locating dominating set

$D = \{x_2, y_1, z_2\}$
 $V \setminus D = \{x_1, y_2, y_3, z_1, z_3\}$
 $N(x_1) = \{y_1, y_2\}$
 $N(y_2) = \{y_1, y_3, x_1, x_2\}$
 $N(y_3) = \{x_2, y_2, z_3\}$
 $N(z_1) = \{z_2, y_1\}$
 $N(z_2) = \{z_1, y_2, y_3\}$
 $N(x_1) \cap D = \{y_1\}$
 $N(y_2) \cap D = \{y_1, x_2, z_2\}$
 $N(y_3) \cap D = \{x_2\}$
 $N(z_1) \cap D = \{z_2, y_1\}$
 $N(z_3) \cap D = \{z_2\}$

Symbol of locating Dominating set

There are 3 points dominator on graph $n = 2$

known point apart from dominator

Given also the point that side by side with $V \setminus D$

found result slice in different means penentuan titik dominator correct proven.

④ Kesimpulan

$\delta(r_2) = 5$
 $\delta(r_3) = 5$
 $\delta(r_4) = 6$
 Jadi $\delta(r_n) = \frac{3n+1}{2}, n \text{ ganjil}$
 $\frac{3n}{2}, n \text{ genap}$

Known locating results Dominating set at n odd and even

lead to the conclusion with formula n odd and even

2. Subject 2 (TBK 3), Ratna Damayanti

① Menentukan graf beserta ekspansinya

No listed the name of graph

Unknown how many graph n

Cardinality determination under proved to be true, to graph above

② Menentukan kardinalitas

$V = \{A, x_i; 1 \leq i \leq 2n\}$
 $|V| = 2n + 1; n \geq 2$
 $E = \{Ax_i; 1 \leq i \leq 2n\} \cup \{x_i x_{i+1}; 1 \leq i \leq n\}$
 $|E| = 3n; n \geq 2$

③ Menentukan Locating Dominating set

symbol locating Dominating set

3 points dominator

point apart dominator

result different slices, LDS proved true

$D = \{x_1, x_3\}$
 $V \setminus D = \{A, x_2, x_4\}$
 $N(A) = \{x_1, x_2, x_3, x_4\}$
 $N(x_2) = \{A, x_1\}$
 $N(x_4) = \{A, x_3\}$
 $N(A) \cap D = \{x_1, x_3\}$
 $N(x_2) \cap D = \{x_1\}$
 $N(x_4) \cap D = \{x_3\}$

$D = \{x_1, x_3, x_5\}$
 $V \setminus D = \{A, x_2, x_4, x_6\}$
 $N(A) = \{x_1, x_2, x_3, x_4, x_5, x_6\}$
 $N(x_2) = \{A, x_1\}$
 $N(x_4) = \{A, x_3\}$
 $N(x_6) = \{A, x_5\}$
 $N(A) \cap D = \{x_1, x_3, x_5\}$
 $N(x_2) \cap D = \{x_1\}$
 $N(x_4) \cap D = \{x_3\}$
 $N(x_6) \cap D = \{x_5\}$

④ Kesimpulan

$S(DR_2) = 2$
 $D = \{x_1, x_3\}$
 $S(DR_3) = 3$
 $D = \{x_1, x_3, x_5\}$
 Jadi $S(DR_n) = n$

Dominator known the results of each graph

Graph formula besides no information, apply for n odd or even

3. Subject 3 (TBK 2), Recha Batista

No names grap

① Membuat grap beserta ekspansinya

Not clear F is a symbol of what gap name

② Menentukan kardinalitas

$V = \{x_i; 1 \leq i \leq 2n\} \cup \{y_i; 1 \leq i \leq n+1\}$
 $|V| = 3n+1$
 $E = \{x_i y_i; 1 \leq i \leq 2n\} \cup \{x_i y_{i+1}; 1 \leq i \leq n\} \cup \{x_{i+1} y_i; 1 \leq i \leq n\}$
 $|E| = 4n$

Determinatio cardinality is correct

Writing the wrong side symbol, which correct is only E

The above results are the works done by S1, S2 and S3. Here are the results of interviews with subject 1 (S1), the subject 2 (S2), and subject 3 (S3) in solving the problem of locating Dominating set class.

1. a. Interview with S1 (student name)
(TBK 4) Problem number 1

S1 : Ma'am, is it okay to do the graph this way?

P : It's okay. What is the name of the graph you created?

S1 : Is it fine if I name it home?

Q : Please, carry on. But make sure that the result is aligned with the graph.

S1 : for the notation can I use x, y, and z, Ma'am?

Q : Sure you can.

S1 : Okay thank you Ma'am.

P : Yes. You are welcome,

From the interviews above, it is clear that student S2 is very meticulous in determining graph, as seen from the response given by S1.

b. Interview with S1 Problem number 2

S1 : Ma'am, I try to determine the cardinality graph $n = 2$, the result is like this and if $n = 10$ means very long I write cardinality Ma'am.

Q : Do you remember the cardinality exemplified earlier on the board?

S1 : yes Ma'am, I do. This I noted. What's the matter Ma'am?

P : try to pay attention to how you can generalize it. Only then you can avoid working too much upon determining the cardinality.

S1 : I see, sorry. Let me give it a go, Ma'am.

Q : OK. Please carry on.

Based on the interview, it is clear that S1 was at first confused with how to determine the cardinality as he was not well prepared and did not pay attention to the examples previously given. However, S1 was very clever and quick to understand something new, and the result was very good, S1 could complete the question well and correctly according to what has been taught by the researcher.

c. interviews with S1 Question 3

Q : how is question number 3, can you do that?

S1 : Insya Allah (seems like we can) Ma'am.

P : If you've found a dominator point, try to check whether your graph meets the known dominator point.

S1 : Yes ma'am I have tried in about $n = 5$, and the results are patterned.

Q : Okay, so it means you have succeeded

in determining dominating set. Please proceed to the next question.

S1 : Yes ma'am, ready. Thank you ma'am.

Q : All right.

As seen from the interview above, it is clear that S1 did not have a problem to solve the number 4. That means S1 has mastered the material.

d. S1 interview question number 4

Q : Do you have difficulty in determining the number and dominating set to find the formula?

S1 : Alhamdulillah (Thanks god) I found no difficulty.

Q : Alhamdulillah, good then.

From this brief interview, we can conclude that S1 found it very easy to solve question number 4, and there were no problems at all, it means that the S1 was very creative in solving problems.

2. a. Interview with S2 (student name)
(Critical thinking level 3) Problem number 1

Q : What are difficulties you experienced when determining new graph?

S2 : No trouble ma'am, God has directed my imagination to make this graph. After that, I immediately proceed to the next step.

P : Okay, when you have to determine notation, are there any difficulties?

S2 : Maybe if I was given a new graph done by others, I would have difficulty Ma'am, because they do not understand the plot. But in my graph, I found no trouble, because I made a graph similar to what you had previously shown.

Q : Okay.

Judging from the above conversation, S2 found no trouble in finding the new graph, because when trying to create graph, S2 did not take a long time. He could immediately figure it out. But, S2 said that if given a new graph done by others, it might be difficult to resolve.

b. S2 interviews with Question 2

Q : What do you know about cardinality?

S2

Q : In determining the cardinality, is there any trouble?

S2 : No Ma'am

Q : Alhamdulillah. Good then.

S2 does not seem to have difficulties in determining cardinality, after researchers looked at the results of S2 on question 2. He could finish the problem properly.

c. interview with S2 Question 3

P : After completing question 3 especially dealing with determining locating dominating set, what

have you learnt?

S2 : I found that to determine locating dominating set was very difficult, because many failed attempts I did. After a few minutes I did finally find locating the Dominating set. It turned out that it was unique material. It made me curious.

P : Well, with a sense of wonder of that kind, then you have proven that you are successful at Dominating set. Keep it up.

S2 : Yes Ma'am thank you.

From the interview above, S2 is very interested in the lesson, because this material is very unique and intriguing. Usually with curiosity possessed, students will gain the spirit of learning.

d. interview with S2 Question 4

P : On question 4, concluded by Dominating number, do you find it difficult?

S2 : If you've found locating graph Dominating set for all the odd and even sets, it is not difficult to conclude. It's simply like searching and matching Ma'am.

Q : Matching?

S2 : yes mean after I found the formula in conclusion, I match whether the conclusions which I determine are correct.

Q : I see, okay thanks.

It can be seen from the above interviews that S2 does not find any difficulty in concluding formula in Locating Dominating sets when dominating number to graph odd and even has been found.

3. Interview with S3 (student name) (Critical thinking level 2)

a. interview with S3 Question 1

Q : How do you find the new graph?

S3 : Initially I make a scribble on blank paper Ma'am, thoughtfully, I was thinking about whether the graph I created would make perfect graph. After that, once I found graph, it turned out that it had something in common with my friend's. Finally, I replaced a new graph, until I discovered that I made this graph.

Q : In your opinion, is it a difficult question?

S3 : Yes it was difficult Ma'am. It took quite a long time to find a new graph. And it got me confused. I am looking for ideas for this graph.

P : Well, that is important to be enthusiastic in seeking graph, I guess. Also it is important not to be desperate to find a new graph.

S3 : Yes ma'am. Thank you

Q : You're welcome.

The conversation above shows that the S3 found it very difficult to determine a new graph. According to her

response, it required a very long time to create a graph. Moreover, he thought that her work should not be the same as her classmates'. However, S3 was able to find a new graph.

b. S3 interview with Question 2

P : Well, on question 2, to find cardinality, are there any difficulties?

S3 : at first there might be problem, Ma'am, because at first I tried to determine my cardinality, yet it was not generalizable. But after that I worked with a friend next to me, and finally I was able to determine the cardinality of graph I created.

Q : Okay if so. Would anyone like to ask?

S3 : No, Ma'am.

P : All right then.

From the conversation above, it can be seen that the S3 has been accustomed to determining cardinality which is not generalizable. Although generalizations can facilitate students, with the lack of communication with his peers, S3 finally was able to finish the problem.

c. interview with S3 Question 3

Q : In determining locating Dominating set, did you work on your own?

S3 : Yes Ma'am

Q : Is there any problem?

S3 : The difficulty was when understanding the existing point Ma'am. That made it difficult and it took a long time.

Q : Do you feel bored when you searched the dominator point?

S3 : Not at all Ma'am, but irritated, as the result of the cut was always the same.

Q : But it is unique right?

S3 : Yes Ma'am.

Q : There is a silver lining in every cloud, right? So, your patience will be trained. Please, continue.

S3 : yes Ma'am.

From the interview above, S3 difficulty in determining the dominator point, but with patience he did eventually manage to solve the issue.

d. interview with S3 Question 4

Q : For question number 4, I think there is nothing wrong in writing. Maybe you have less scrupulous, or was tired because it was irritated by Question 3 earlier.

S3 : No Ma'am, it's because I lack the focus on the writing.

Q : Do you find something wrong?

S3 : Yes Ma'am there are some. It should be but I write f. Sorry Ma'am.

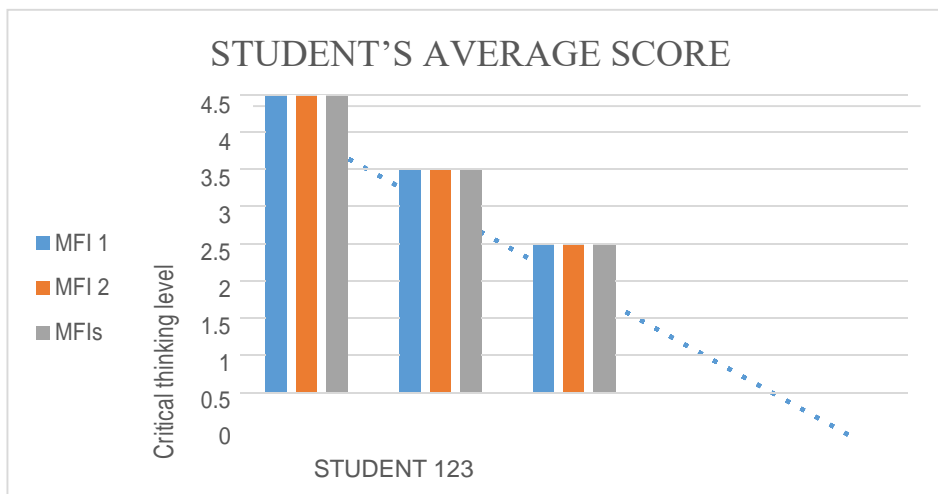
P : Okay, no problem. Next time you must be thorough and focused.

S3 : Yes Ma'am.

From interviews with S3 above, it is clear that S3 was hardly careful in doing the task, eventually an error

occurred.

The following diagram shows the students' average score on test package A, B, and C.



The results of the analysis of creative and innovative thinking skills of students can be classified into four levels of creative thinking and the three indicators. Of the 34 students, drawn 3 students who score critical thinking level 4, 3, and 2. It is also clear that every student has a different character in accomplishing the test package A, B, and C. Of the three students analyzed according to the results of the test class for 3 meetings, no student achieve 0. This critical thinking level indicates that the students are creative and innovative in solving problems, especially in resolving locating dominating set.

IV. CONCLUSION

Researchers/lecturers can apply this research into learning through RBL methods so that students would know the progress of the latest research, and students gain experience in conducting research. Students will be directed to a higher level thinking of creative and innovative thinking. Being creative in this study relates to how students can find a new graph that has not been previously investigated and the findings of these students are then analyzed to determine the level of creative and innovative thinking of the students. Based on the results, the application of RBL method to analyze the creative and innovative thinking skills of students revealed that, out of 34 students, 3 students achieved critical thinking level 4, 3, and 2. Also, the study reveals that the student has a different character in accomplishing the test package A, B, and C. Of the three students analyzed according to the results in test class for 3 meetings, the results show no students achieving critical thinking level 0. This means that the students are creative and innovative in solving problems, especially in resolving locating dominating set.

Based on those results, we propose the following suggestions for further research:

1. How can RBL be applied in other research studies?
2. What is the novelty in assessment obtained in the application of the RBL?
3. What are the obstacles faced by researchers when applying RBL in learning?

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REFERENCES

- [1] AD Jumani, L. Chand, Dominating Number of Prism Cycle over C_n , Sindh University Research Journal (Science Series), Sindh Univ. Res. Jour. (Sci. Ser) Vol.44 (2) 237-238 (2012).
- [2] Afidah et al. 2012. The Influence Of Application Method Socratic Circles With Images Media Toward Student's Creative Thinking Skill. Vol 4. No. 3. 1-15.
- [3] Anonymous. 2015 "21st Century Student Outcomes". P21 Partnership For 21st Century Learning: 3.
- [4] Argiroffo, GR, Bianchi, SM .2015. "A polyhedral Approach to Locating Dominating Sets in Graphs". Electronic Notes in Discrete Mathematics, 50: 89-94.
- [5] Arvyati et al. 2015. Effectivity Of Peer Tutoring Learning To Increase Mathematical Creative Thinking Ability Of Class XI IPA KendariSman 3, 2014. International Journal of Education and Research, Vol. 3 No. 1 January 2015, pages 613-628.
- [6] Caroli, ME and Sagone E., 2009. Creative Thinking And Big Five Personality Factors Of Measured In Italian Schoolchildren. Sage journals, Vol 105, Issue

- 3,
2009.[http://journals.sagepub.com/doi/pdf/10.2466/P
R0.105.3.791-803](http://journals.sagepub.com/doi/pdf/10.2466/P
R0.105.3.791-803).
- [7] Chamdani et al. 2015. Based Learning Model Development Research Scientific Approach Through Lesson Study in Learning Ips Primary Schools Year 2015. Proceedings of the national seminar on education. Ponorogo: Guidance and Counseling, University of Muhammadiyah.
- [8] Dafik. 2015. Handbook for the Implementation of RBL (Research-Based Learning) in the Courses. Jember: Jember University.
- [9] Dafik. 2016 PBR Development (Research Based Learning) in a subject.
- [10] Environmental Impementasi Unej PBR. Jember: Jember University.
- [11] Foucaud, F. Henning, MA 2016. "Locating-Dominating Sets in Twin-Free Graphs".
- [12] *Journal of Discrete Applied Mathematics*, 200: 52-58.
- [13] Khamdit, Sinthawa. 2014. Research-Based Learning (RBL) in Higher Education.
- [14] SUTHIPARITHAT Vol.28 # 85 January - March, 2014.
- [15] Siswono, EkoYuliTatag. 2011. Level of student's creative thinking in mathematics classroom. *Educational Research and Review* Vol. 6 (7), pp. 548-553, July 2011, ISSN 1990-3839 © 2011 Academic Journals.
- [16] Slater, PJ 2002. Locating Fault-Tolerant Dominating Sets. *Discrete Mathematics*, 249: 179-189.