The impact of an exploratory approach in teaching mathematics to students’ creative thinking abilities

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Abstract. The purpose of this study is to determine the impact of an exploratory approach on the creative thinking abilities of Junior High School students in Bengkulu City. This type of research is experimental research with Posttest-Only Control Group Design. The research sample is 87 students of 8th grade at SMPN 1, SMPN 11, and MTs Ja-Al Haq in the second semester of 2019/2020 Academic Year. Based on the Kruskal-Wallis H test, the asymp value is 0.00 smaller than 0.05, so there is differences in students’ creative thinking abilities, which is taught by using an exploration approach to teaching mathematics in high, middle and lower level schools. The average value of students’ creative thinking skills from each school level is as follows: upper level school is 63.34; middle level schools is 59.38, and lower level school is 49.27. The ability to think creatively High School Junior high level students better than lower school students. The ability to think creatively of middle level Junior High School students is better than lower level school students. However, based on the Mann-Whitney test, a significance value of 0.489 is greater than 0.05 between the ability of the creative thinking of high school students and middle school students. So, there is no difference in the ability to think creatively High School Junior high school students with middle school students.

1. Introduction
The creative thinking ability of students in Indonesia is still low. This can be seen in the results of the completion of PISA (Program for International Student Assessment) mathematics problems by students presented by The Organization for Economic Co-operation and Development [1] who scored 379 below the average of 489. Indonesia ranks 71 out of 78 countries. PISA 2018 questions emphasize the development of 21st century skills, namely creative thinking and problem solving. The weakness of students’ creative, especially in the aspect of original thinking [2]. Apart from original thinking, other aspects of creative thinking skills are thinking fluency and flexibility [3].

Students’ ability to think creatively in mathematics can be developed through creative teachers [4], creative problem solving [5], realistic mathematics education [6]. Teacher creativity, problem solving steps, and realistic mathematics education activities that are based on student activities and discovery activities are included in exploration activity [7].

The formulation of the problem in this study are:
1. Are there differences in the creative thinking abilities of students who are taught using an exploratory approaches at high, middle, and lower levels of school?
2. How is the creative thinking ability of students at the upper, middle, and lower levels of school?

Creative thinking is a form of thinking that produces something new and unexpected\(^8\). Creative thinking requires an irregular way of solving a problem\(^9,10\). In addition, creativity can be defined in multiple ways, involving cognitive processes, personality characteristics, and environment variables, as well as the interaction of these components\(^11\).

Creative thinking is thinking that contains components of fluency, flexibility, authenticity, and elaboration\(^12\). Indicators of creative thinking are as follows: fluency, flexibility, authenticity, and elaboration\(^13\). In addition to original aspects, creative thinking also consists of aspects of creative thinking, flexibility, novelty, synthesis, analysis, reorganization, complex, and elaboration\(^14\). Another feature of creative thinking is divergent thinking. Divergent thinking is thinking that looks at various aspects. In addition, creative thinking is a thinking activity that finds solutions to a problem in various ways\(^15\). Another characteristic of creative thinking is being able to contact mathematical ideas with a wider context\(^16\). The aspects of creative thinking skills are thinking fluency, flexibility, and originality.

The exploratory approach is an approach that aims to explore different ideas, arguments, and ways from students through a number of open questions and commands so that they can lead students to understanding a concept and solving a problem\(^18\). The exploratory approach rests on activities in exploring its ability to understand a concept or to solve a problem. Therefore, this approach is based on constructivist understanding.

The stages of the exploratory approach are as follows\(^19\): (1) The preparation stage, the teacher prepares various learning tools and various facilities for exploration activities to take place. (2) The exploration stage for the discovery of new concepts, namely the stage where teachers and students explore mathematical concepts, principles, and skills. This stage begins by identifying the objects of various elements that compose them. The social phenomenon of people of Japanese and African descent to obtain the influence of American culture on immigrants\(^20\). (3) The exploration stage of the application of new concepts, in which teachers and students apply various mathematical concepts, principles and skills to new situations. The closing stage, the teacher and students conclude new findings from the mathematical concepts, principles, and skills they have learned.

2. Methods
The design of this research is a quasi-experimental design. Research subjects in the form of 8\(^{th}\) grade students who have been formed in classes at upper level schools (SMPN 1 Bengkulu City), middle level (SMPN 11 Bengkulu city), and lower level (MTs Ka-Al Haq) as many as 87 people as a sample in this study. Research activities are carried out in the even semester of the 2019-2020 Academic Year. Quasi-experimental design as follows: \(\frac{x - \bar{x}}{s}\), \(x\) represent the experimental treatment in the form exploratory approach, \(\bar{x}\) represent the posttested.

The research instrument was in the form of essay questions on the ability to think creatively as many as 4 items about prisms. The results of the instrument trial showed that the 4 creative thinking questions were valid with each correlation value \((r)\) as follows: \(r\) item 1 = 0,441, \(r\) item 2 = 0,739, \(r\) item 3 = 0,674, and \(r\) item 4 = 0,726 is significant 0,005 with the calculated \(r\) value greater than \(r\) table = 0,349. Meanwhile, the reality value of Cronbach’s alpha is 0,484 and is located in the interval 0,4 ≤ \(\alpha\) ≤ 0,6 with sufficient reliability criteria. This shows that the instrument can be reliable enough to be used in research.

3. Results and Discussion
The activity of using the exploratory approach in learning mathematics with the topic ‘Prism’ was conducted in a conducive manner. The stages of the exploration approach are carried out well by the teacher. The preparation stage, the teacher prepares the topic ‘Prism’ learning tools, such as:
RPP, syllabus, student worksheet, media, and evaluation tools. Exploration stage of a new concept about ‘Prism’: a. The preparation stage, b. The exploration stage of the discovery of new concepts, c. The exploration phase of the application of new concepts [21]. The learning preparation stage in the exploration approach is that the teacher prepares all learning tools for use by teachers and students in exploring the form of lesson plans, syllabus, and learning media. The form of learning tools is exploration-based. Various needs of students for exploration are prepared in this activity, such as media in the form of objects in the form of prism and objects or other tools that support the prism. The results of the validation test of learning tools (lesson plans, syllabus, and learning media) by 5 panelists stated that the learning tools were valid.

The implementation of learning using an exploratory approach takes place dynamically. The teacher begins the lesson by conveying learning objectives, outlining the subject matter and conveying motivation to students. The teacher explores the students’ prerequisite material abilities. After that, the teacher explores the material systematically, starting from the introduction (the easy thing) to finding and applying concepts.

The activity of discovering the concept of understanding the prism through observing a ‘swimming pool’. The teacher asks students to name the base area, the top plane (water level), and the vertical ribs. The prism volume concept discovery activity was carried out by the teacher who asked the students to name the amount of water in the swimming pool. While the application of the concept through the use of the volume prism concept in solving problems in everyday life, namely calculating the volume of the water bath in each student’s house.

The impact of applying the exploratory approach is the formation of students’ creative thinking abilities. Students are able to produce new things (authenticity) in solving a problem. As in solving problems calculating the length of a wire in the form of a prism-shaped object. The form of calculation can be done in 9 ways. One way is shown in the following Figure 1.

![Figure 1. Problem solving by students](image)

The way these students do is as follows. The length of the wire needed to form a prism-shaped object is 2x(3x6) + (3x8) = 2x18+24 = 2x18+24 = 36+24 = 60 cm. The students solved the problem smoothly without stopping. The flexibility of the students’ way of thinking in solving these question is marked by a flexible way of solving the questions exemplified by the teacher. Thinking elaboration shown by students by linking various operations and concepts in solving a problem. The operations and concepts used by students in solving the above problems are addition, subtraction, multiplication, addition/multiplication associative concepts.

The results of students’ creative thinking abilities taught through an exploratory approach are shown in Table 1.
Table 1. Students’ creative thinking abilities based on school level

| Data      | School A | School B | School C |
|-----------|----------|----------|----------|
| N         | 26       | 32       | 29       |
| Min score | 25       | 10       | 40       |
| Max score | 58       | 78       | 100      |
| Mean      | 49.27    | 59.38    | 63.34    |
| SD        | 6.44     | 18.38    | 15.36    |

Note:
School A = Lower level school (MTs Ja-Al Haq)
School B = Middle level school (SMPN 11 Kota Bengkulu)
School C = Upper level school (SMPN 1 Kota Bengkulu)

Based on Table 1, the average creative thinking ability of high school students (C) is 63.34 and medium level school students (B) is 59.38. The creative thinking abilities of students from both school are included in the medium category. While the creative thinking ability of lower level school students (A) of 49.27 is included in the low category. The ability to think creatively for high school students is better than middle school and lower level students. In detail, students’ creative thinking abilities from the three school levels are presented in Table 2.

Table 2. Components of students’ creative thinking abilities Based on school level

| No. | Ability to think creatively | Bottom School | Middle School | Top School |
|-----|-----------------------------|---------------|---------------|------------|
| 1   | Fluency                     | enough        | enough        | good       |
| 2   | Flexibility                 | good          | good          | good       |
| 3   | Authenticity                | enough        | enough        | enough     |
| 4   | Elaboration                 | enough        | good          | good       |

The details of the creative thinking abilities based on the school level show that the creative thinking abilities of top school students are good in terms of fluency, flexibility and elaboration thinking ability category good. Meanwhile, the category of ability to think fluently and authenticity. Bottom level school students, the category of flexible thinking ability is good, the rest is in enough category. All students who come from top, medium, and bottom level schools, the category of flexible thinking ability is good, the rest is in enough category. All students who come from top, medium, bottom level schools have a sufficiently authentic thinking ability category.

The ability of top high school students to think creatively in terms of fluency, flexibility, and elaboration, while the aspect of authenticity is sufficient. Medium level school students, the flexibility and elaboration thinking ability to think fluently and authenticity. Bottom level school students, the category of flexible thinking ability is good, the rest is in enough category. All students who come from high, medium and low level schools have a sufficiently authentic thinking ability category.

Medium level school students, the flexibility and elaboration thinking ability category is good. Meanwhile, the category of ability to think fluently and authenticity. Lower level school students, the category of flexible thinking ability is good, the rest is in enough category. All students who come from high, medium, and low levels schools have a sufficiently authentic thinking ability category.

The research hypothesis test begins with the requirements test, namely the data normality test using the Kolmogorov-Smirnov test. The results of the normality test obtained that the data were not normally distributed with a low-level school statistic value of 0.243, a medium-level school of 0.208, and a high-level school of 0.1999. Therefore, a hypothesis test was carried out using a non-metric statistical test, namely Kruskall Wallis.
The results of hypothesis testing using the Kruskall Wallis test obtained a statistical score of 19,119 with df=2 and asymp. Sig. 0.000, which means accepting Ha, which means that there are differences in students’ creative thinking abilities in the three schools. This is shown in Table 3.

**Table 3. Test of creative thinking skills**

| Creative score          |
|-------------------------|
| Kruskal-Wallis H        | 19,119 |
| df                      | 2      |
| Asymp. Sig              | .000   |

The mann-Whitney test was used to determine in more detail the differences in creative thinking abilities between the two schools. Table 4 shows the results of tests of creative thinking skills between students from low level schools (A) and students from middle level schools (B).

**Table 4. Mann-Whitney test of creative thinking skills**

| Between schools A and B | Creative score |
|-------------------------|----------------|
| Mann-Whitney U          | 163,500        |
| Wilcoxon W              | 514,500        |
| Z                       | -3.977         |
| Asymp. Sig. (2-tailed)  | .000           |

Based on Table 4, it can be seen that there are significant differences between students in schools A and B in their creative thinking abilities. The mathematical creative thinking ability of school B students (middle level school) is significantly higher than lower level school students (A). Middle level students’ elaborate thinking skills are better than low-level schools. Middle school students are able to combine various rules in solving a problem. The two groups of students have different thinking styles. Thinking style affects students’ creative thinking ability [22].

The following is presented in Table 5, the results of the creative thinking ability test of students from low-level schools (A) and students from high-level schools (C).

**Table 5. Mann-Whitney test of creative thinking skills between schools A and C**

| Creative score     |
|--------------------|
| Mann-Whitney U     | 162,000          |
| Wilcoxon W         | 513,000          |
| Z                  | -3.656           |
| Asymp. Sig. (2-tailed) | .000           |

Table 5 shows that there are significant differences between students in low-level schools (A) and high-level schools (C) in creative thinking abilities. The creative thinking ability of students in school C is significantly higher than that of school students A. The ability to think fluently at school level students is better than students at low level. High school students only need a short time to solve a problem. Students at the high school level have better intelligence with students at the lower school level. Mathematics learning is carried out at high school based on multiple intelligence. Multiple intelligence based learning can improve students’ creative thinking skills [23].

While the differences in the creative thinking abilities of students from middle level schools (B) and upper level schools (C) are shown in Table 6.
Table 6. Mann-Whitney test of creative thinking skills between B dan C

|                      | Creative score |
|----------------------|----------------|
| Mann-Whitney U       | 416,500        |
| Wilcoxon W           | 944,500        |
| Z                    | 0.691          |
| Asymp. Sig. (2-tailed)| 0.489          |

From Table 6, it appears that the difference in the creative thinking abilities of middle school students (B) and middle school students (C) is not significant. The flexible thinking and elaboration are the same. Meanwhile, the ability to think fluently and originally from the two schools is different, but not significant. Students from high and middle level schools are equally fluent in solving problems, but the strategy used by high school students is better than middle school students. Good strategic planning can make it easier for students to solve a problem.

4. Conclusion
1. The average creative thinking ability of upper-level school students is 63.34 and middle-level school students are 59.38. The creative thinking abilities of students from both school are included in the medium category. Meanwhile, the creative thinking ability of lower level school students was 49.27 in the low category.
2. There are differences in the creative thinking abilities of students who are taught with an exploratory approach with a conventional learning approach at upper, middle, and lower levels of school. However, the difference in the creative thinking ability of junior high school students and middle school students is not significant.
3. High level school students have better creative thinking skills than middle and lower school students. Middle level school students have better creative thinking abilities than lower level students.

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