Correlation between mathematical creative thinking ability and mathematical creative thinking disposition in geometry

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Abstract. Mathematics educators commonly believe that an open-ended approach could facilitate students to build their creative thinking ability and its disposition, especially in geometry. This research belongs to a quasi-experiment that used a non-equivalent control group design. The purpose of this research was to analyze the correlation between creative thinking ability and creative thinking disposition through an open-ended learning approach toward area and volume of flat geometrical objects problems. Two classes are selected as the sample, they are the control group and experiment group. The open-ended approach was used in the experiment group then direct instruction in the control group. The population is all of the eighth-grade students at one of the junior high school in Bandung, West Java, Indonesia. This study used test and non-test as the research instruments. The test instrument was a creative thinking ability test while the non-test instrument was a questionnaire. These instruments were given after the learning process then analyzed by using Bivariate Correlation through SPSS. According to the analysis results, the finding is: the correlation coefficient between creative thinking ability and creative thinking disposition is at the middle level. The conclusion is there is a significant correlation between students’ creative thinking ability and students’ creative thinking disposition.

1. Introduction
Learning mathematics always involves mental activities. Students have to find a way for solving a problem in mathematics. Therefore, it cannot be separated from the thinking process. Think is a mental activity. The thinking process covers brain activity to find information with product ideas or concepts. Based on the psychology of Gestalt, thinking is an invisible activity in which the process cannot be observed by our five senses. According to Plato, thinking is a heart speak. Therefore, the thinking process of a person cannot be seen directly.

Studying and learning processes need a thinking activity naturally to obtain the lesson from the teacher, to understand the concept, and to find a way to complete a problem. The learning process should not be focused on the basic skills which are always dominated by a routine exercise then resolved by convergent thinking through memorizing and repetitions the sample settlement hat given by the teacher. It should generate higher-order thinking skills through divergent thinking [1].

Divergent thinking is important in solving usual problems with construct all possible solutions from all perspectives. It is very essential in the learning process which is not only based on a single answer but also all possible answers within construct many ways to resolve them. Divergent thinking
enables all possible procedures to find the answer using the unique ideas and complex argumentation. It causes the solution is correct and reasonable therefore, we can apply it in solving problems in real life.

Divergent thinking ability can be developed student’s creativity [2]. It can resolve mathematical problems with non-procedural steps by seeking the other perspective of the problems. Students who have the divergent ability can create some opinions or arguments to resolve the problems therefore it can be resolved using many ways and answers.

However, the fact shows that most students keep on thinking convergently. Most of them are have procedural thinking, which follows the steps of problem-solving based on the way that is given by the teacher. Most students find some difficulties with seeking opinions or ideas in solving mathematical tasks. The problems can be resolved not only in a specific way but also in non-procedural ways. Mathematical problems do not only seek a single solution in the usual way but also it might have many answers in unique ways. Convergent thinking indicates the lowered students' creativity.

Creativity is a potency in every individual that includes ideas or argumentations that can be combined or developed, so it can create or produce a product that will give benefit for them and their surroundings [3]. The ideas or argumentations merge through a process of thinking, it is called creative thinking. The new ideas and argumentations are applied in solving problems. Creative thinking is one type of mathematical higher-order thinking skills. It includes activities in doing mathematics using the brain processes that cannot be observed directly but the result can be analyzed. It is also the ability to identify relationships between two ideas that are not clear.

In the same aspect, thinking mathematically is generally defined as the process of conducting math and mathematical tasks. According to the terms of depth or complexity that involve mathematical activities, mathematical thinking can be classified into two types, low level, and high level. Low levels of mathematical ability are routine and simple and can be solved by most of the students such as direct application of the concept and a simple computational or procedural. In contrast, the ability of higher-level mathematical thinking is not routine. It is more complex and requires different mathematical ability to carry it out. Therefore, creative thinking is one of the mathematical abilities with high-level skills [4].

The ability of creative thinking is a potency to formulate many ideas and apply them in solving problems [5]. This is also the ability to identify relationships between two ideas that are not clear. The characteristics of creative thinking abilities include fluency, flexibility, original and elaborate [6]. Fluency is a skill to conduct many arguments to solve problems or questions fluently and to provide many ways or suggestions in solving the problem and be able to think more than one answer. Flexibility is a skill to generate various arguments, answers, questions through the direction of an alternative solution of a problem. Flexible means seek an issue from many points of view using out of mind thinking or approach for the solution of a mathematical problem. Originality is a skill to give growth to the newer and unique expression [7]. It relates to the ability to think of a way or a combination of problem-solving which is not uncommon. Elaboration is a skill to develop the arguments or solutions by specifying every part of an object, idea, and state of the problem.

Students who can think creatively will be able in doing mathematical problems with higher ability. They have a strong sense of confidence and feel challenged to solve problems though they are not well-mastered. Also, creative students can evaluate their ideas from another point of view to found the best idea. Students who have creative tasks are based on internal motives, not external motives. It means students are being proactive persons, not a reactive one.

Creative thinking is a thought process for finding new ideas, views, ways, or connecting relationships to find new connections in understanding things [8]. Creative thinking also includes convergent, divergent, and lateral thinking ability. Divergent thinking means to seek something out of mind with a usual point of view, propose alternative solutions, being open and flexible. Convergent thinking means that being able to formulate a mathematical hypothesis based on a causal relationship to the mathematical situation, determine the mathematical patterns, propose new solutions when faced
with deadlock thinking, propose an unusual idea and assess its consequences as well as being able to identify missing information and detailing common problems into more detailed issues [6].

Creative thinking ability can grow up a student's self-confidence and objectivity. Students can appreciate the beauty of mathematics through their self-confidence and they also can develop their open-minded objectively. These goals are useful to face the future that usually changed and grow continuously. The attitudes and the habituation of thinking are accumulatively rising a disposition through mathematics [6]. Creativity appears through the strong motivation and the higher spirit of the students. A disposition in creative thinking will grow accumulatively when the habits of creative thinking appear continuously.

According to NCTM, the disposition is the passion, the positive attitude, and appreciation in doing mathematics [6]. The students who have a disposition in mathematics feel mathematics is attractive. They love mathematics and also thinking and acting positively when doing mathematics. Creative thinking disposition is a desire, passion, spirit, and powerful dedication when doing something creative in mathematics in positive ways [6]. The characteristics of creative thinking disposition: (1) open-minded, flexible, tolerant with different ideas and uncertain problem; (2) create the ideas and feel free, enjoy to ask; (3) appreciate the imagination; high initiative; have the original ideas; (4) have unique ideas and not affected easily; (5) have the personal image and emotional stability; (6) self-confidence and reliable; (7) have anxious fantasy and interested for abstraction, complex and holistic; (8) have a wide interest; (9) brave to face risk, have responsibility and commitment for doing the tasks; (10) diligent and not bored easily; not out of mind; (11) sensitive into environment situation; and (12) more oriented into nowadays and future than past [6].

A positive disposition in creative thinking within students is a must and very important ability for them. The students should have this ability because it can develop a student's positive attitude through creative thinking in mathematics learning. This skill is to promote mathematics goals, education visions, and learning curriculum which is indispensable for facing future challenges. The habituation of this attitude should be grown continuously during the studying and learning activities. The habituation as honesty, discipline, hard-working, responsibility, critical, creative, independent, and curiosity can be built through doing mathematics. This challenge is suitable for students' future needs and their intellect Teachers development. The teacher has to compose a letting situation the student slate the student's superior attitudes accumulatively. It can foster a positive attitude in every part of mathematics activities. The students were trained in creative thinking to ensure improve their achievement and performance mathematics. It is related to the NCTM recommendation to conduct the lesson plan, exercises, and the instruments in studying and learning mathematics to reach the students' attitudes disposition development [6]. Therefore, an innovative learning approach can encourage the students to achieve the ability and disposition in thinking. The learning approach can make students develop, elaborate, and explore their ideas and conjecture through the meaningful learning process actively even by their selves. Studying and learning mathematics should be implemented comprehensively and integrated with all possible situations to develop student's creative thinking ability and its dispositions. It should not be partial and separate therefore the development of the learning environment can support the development of other domains. In this study, we use the open-ended approach.

Open-ended is a learning approach that allows learners to think actively and creatively in solving the problems. Posing open-ended problems can improve creative thinking disposition [6]. The open-ended approach presents an open situation that is constructed in such a way so it has a good variation way and solving process that leads to the solution of the problems [9]. This approach makes students explore their ability to solve problems in various ways or answers. It gives a chance for students to enhance their ability in creative thinking [10]. In the open-ended approach, teachers provide an open problem that the solving steps or the solution is not specified in a single way [11]. In other words, the problem-solving process and the final answer are not solved in one way [12]. Student's creativity is needed to solve those open problems [13]. Therefore, we believe that an open-ended approach can improve their creative thinking disposition. Therefore, we can apply the open-ended approach to
learning activities. We believe this approach can promote both student’s creative thinking ability and its disposition.

The effective learning methods and strategies were designed for analyzing the answers on diversity issues. Divergent thinking and open-mindedness are some of the considerations to construct open problems and good mathematical tasks [6]. There will be a variation about the student’s opinions according to assessment results about the accuracy of calculation, graphing, and reasoning or the rationality of students' solutions. A performance-assessment approach can be used to measure student's skills in completing the task [6]. Learning mathematics should be focused on the implementation of the mathematical process (doing mathematics) instead of memorizing. Students will explore their ability in doing mathematics through an open-ended approach. Students will make an investigation to conduct the conjectures then analyzed it and elaborate on every possible idea to complete the open-ended problem. These steps were believed can promote student’s creativity in thinking. The tasks are open-ended to involve the student actively in creative thinking [6]. Through the open task, the teacher can cross-check another mathematical ability [14]. The teacher can scaffold students to think creatively in mathematics.

The open problems have not only an open situation but also an unlimited condition. The open-ended approach includes student's open activities. These activities are the variation of student's activities on thinking and their mathematical attitude. These activities must constitute a unity [15]. Teachers should write the expected response from the students when developing the lesson plans based on the open-ended approach. Teachers have to give the problem or issue objectively and attractively. These problems have to follow the principle of problem-posing and problem-solving with unique ways, open-minded, and not focus on a single solution. This will make the students easily understand the open situation. The teachers need to give leisure for students to elaborate on the whole situation. The learning steps in the open-ended approach are: (1) problem posing; (2) learning organization; (3) identify and analyze the student responses; (4) conclude [8].

One branch of mathematics that is considered difficult by students is geometry. Geometry is the most difficult topic for students of all mathematical topics [16]. Geometry is related to the shape, size, composition, and proportion of an object and its properties and their relationship to each other. The geometry content requires a higher-order thinking skill and a higher level of visualization [17]. Middle school students do not fully understand the concept of geometry [18] then students have less skill in geometry [19] so that most students are not interested in learning geometry [20]. Otherwise, geometry is an important material because it is closely related to our daily life. Geometry is familiar to students because there are so many things about geometry in our life [20]. Geometry was also an essential subject in the middle school mathematics curriculum [6]. One material that is included in the National Examination is geometry. Learning geometry is crucial [20]. Geometry content that requires a higher-order thinking skill is corresponding with open-ended problems [21]. Students also need creativity to solve open problems in geometry. Therefore open-ended is believed can increase students’ creative thinking ability and its disposition in geometry.

2. Method
This research belongs to a quasi-experiment. This research used a non-equivalent control group design. The experiment and control group were randomly chosen but used the classes that already exist [22]. In this case, treatment is given only the experimental group. In this design, samples were not fully randomized but choose without analyze the equality probability between samples [23]. The purpose of this research was to investigate the correlation between creative thinking ability and creative thinking disposition through an open-ended learning approach. The independent variable of this research is the open-ended approach. The dependent variable is the students’ creative thinking ability and creative thinking disposition.

Two classes were taken as the sample, they are the experiment and the control group using the purposive technique. The sample was taken from the existing classes. We determined the sampling based on certain considerations. Two classes are selected as the sample, they are the control group and
experiment group. The open-ended approach was used in the experiment group then direct instruction in the control group. The population is all of the eighth-grade students at one of the junior high school in Bandung, West Java, Indonesia.

This study used test and non-test as the research instruments. The test instrument was a creative thinking ability test while the non-test instrument was a questionnaire. The test instruments were used with collecting the student’s work to know their ability in creative thinking. The non-test instruments were used in collecting student’s responses to know their disposition to creative thinking. The questionnaire contains a creative thinking disposition scale that was used to know the student’s attitudes in studying and learning mathematics to collect the data about the student’s arguments, ideas, passion, interest, and beliefs in studying and learning mathematics.

The creative thinking ability test was constructed by the teacher to follow its indicators. The test was posed to the students after the learning process, then it was called the posttest. The selection tests aimed to reveal the shape description of students’ creative thinking abilities about the area and volume of flat geometrical objects problems. The data consist of the posttest was first examined by finding the validity, reliability, and level of difficulty. These are used to distinguish matter and test students in obtaining the data form student responses to the questions above. The description with scoring assessment techniques based on the guidelines has been prepared in advance. The number 2 item from 5 items of students’ creative thinking test is shown in Figure 1.

![Figure 1](image_url)

**Figure 1.** Student’s creative thinking ability test

Figure 1 shows that the item test has contained all of the creative thinking ability indicators. Students must have the idea to find the volume of the cuboid first then find the volume of the cube so that they can count the sum of the cube (fluency). Students have to pose many measures of the cube side therefore there will be many possible correct answers (flexible). They will elaborate on their idea with unique and unusual ways to solve the problem (original).

In this study, the non-test data result was collected then analyzed. The data were obtained from the questionnaires about students’ creative thinking ability and disposition. The questionnaire scale about creative thinking disposition was used to obtain students’ creative thinking disposition in solving area and volume of flat geometrical objects problems. The scale was given to the students in both of the experiment group and control group. The scale was arranged with four choices, they are: very often, often, sometimes, and never. These options are used because there would not be a student’s confusion when they fulfilled the creative thinking disposition scale so that it can against the biased of the data.

The data obtained from the questionnaire was ordinal scale. Therefore, we have to convert it to become an interval scale. We used the successive interval method to transform the data. The students as the respondents measured the instrument to make the values into numerical scores, they are 1, 2, 3 and 4. It would be obtained by scoring each value to the ordinal scale. The numerical value would be placed into the interval scale through the transformation process. The conversion is used to examine the statement validity and to calculate its option in the scale based on student’s responses. This
procedure was used to decide whether the scale indicated the disposition when students think creatively.

3. Result and discussion
The results of this study were obtained from the test and the questionnaire reports. These instruments were given to the students in the two samples after taking the learning process as a posttest. The result analysis of the research is carried out by many software such as Microsoft Excel, Anates, and SPSS. Researchers are using tools such as documentation shaped camera photos, videos, and audio.

Test of creative thinking ability test was given for students to obtain their creative thinking ability. This test consists of 5 questions which include all creative thinking ability indicators. This test has been previously tested for the validity, reliability, level of difficulties, and differentiation power. After finishing the learning process, the teacher gives creative thinking ability tests for students as a post test in the experiment and control group. A creative thinking ability test was conducted to determine students’ creative thinking ability in these groups.

The scale or questionnaire was used to obtain a student’s disposition in creative thinking. This scale consists of 24 items which are divided into 12 positive statements and 12 negative statements. SPSS software is used to check out its validity and reliability. After finishing the learning process, the teacher gives a creative thinking disposition scale for students as a posttest both in the experiment and control group. This instrument was conducted to decide students’ disposition in creative thinking in these groups.

The posttest mean and standard of deviation value for students’ creative thinking ability and creative thinking disposition is described in Table 1.

| Group     | Posttest | Post Scale |
|-----------|----------|------------|
|           | X/SD     | X/SD       |
| Experiment| 65.75/19.10 | 67.26/13.97|
| Control   | 57.06/13.22 | 64.13/11.09|

Table 1 shows the mean of posttest value in the experiment group was 65.75, higher than the control group as 57.06. Then the average post scale in the experiment group was 67.26, higher than the average post scale in the control group as 64.13.

Figure 2 is the average of students’ creative thinking ability at posttest and students’ creative thinking disposition at post scale between the groups.
To determine the correlation (association) between creative thinking ability and creative thinking disposition, we used bivariate correlation of Spearman by SPSS 20. Statistical tests have been used to measure the strength of the linear relationship between two variables continuous and interval scale data [17]. The hypothesis test is based on the data in the posttest and post scale of creative thinking ability and disposition in the experiment and control group. Table 2 shows the correlation between creative thinking ability and disposition.

Table 2. Test value of the bivariate correlation of Spearman's rho

| Spearman's rho | Sig.  | Conclusion | Description          |
|---------------|-------|------------|----------------------|
| 0.428**       | 0.001 | Reject H₀ | There is a Correlation |

Table 2 shows that the significant value = 0.001 < α = 0.05 level. Therefore, H₀ is rejected. It means there is a significant correlation between creative thinking ability and creative thinking disposition. The value of Spearman's rho coefficient indicates the magnitude of the coefficient between creative thinking ability and creative thinking disposition, which is 0.428. The positive sign indicated a strong positive correlation. It means that the students who have a higher score in creative thinking ability also have a higher score in creative thinking disposition. The correlation coefficient between creative thinking ability and creative thinking disposition is at the middle level.

The student's ability in creative thinking make them used to think divergently. Divergent thinking is a thinking habit to analyze mathematical problems from all possible perspectives then construct all possible solutions [24]. Divergent thinking is not to seek a single solution but seek how to construct all possible solutions using all possible procedures with its argumentation, how the solution is correct, and logic so that it can be applied in solving problems in daily life that usually more complex and unpredictable. The student's worksheet that shows the habituation of thinking divergently that indicates student's creative thinking ability is shown in Figure 3.

Figure 3. The student’s answer sheet

Figure 3 showed that the student can conduct his argument fluently to solve the problem. He seeks for the volume of the cuboid first, then he can seek many correct answers with posed many possible side lengths of the cube (fluency). Then he develops his argument to seek the number of the cubes (elaborate). Finally, he can answer the number of cubes with 3 different correct solutions (flexible). All of these steps have uniquely come from his ideas without collab with his friends (original). We conclude that he has a creative thinking ability.

The student also has a positive attitude in learning according to the questionnaire reports. The student has high motivation and spirit in learning. He has a higher curiosity because he was open-minded, diligent, wise, and also often to ask about the lesson. His attitude indicates a positive creative
thinking disposition. Therefore there is a positive correlation between creative thinking ability and creative thinking disposition.

Based on the result analysis of the correlation between creative thinking ability and creative thinking disposition, it was known that the correlation between creative thinking ability and creative thinking disposition is significant. It means that there is a strong correlation between them. The ability of students' in creative thinking makes students familiar with divergent thinking, which is the habit of thinking to observe math problems from all perspectives and construct all possible solutions. Divergent thinking is not learned to find the correct answer (single solution) which is the goal of any solution to the problem, but it is learned to figure out the construct of all the possible answers, procedure, and arguments, why the solution is correct and reasonable, therefore it can be applied in other real problem solving which is usually more complex and unpredictable [25].

If the habit of creative thinking that takes place on an ongoing basis, it will grow cumulatively as a disposition to think creatively, which is called creative thinking disposition. It shows that there is a strong correlation between students’ creative thinking ability and students’ creative thinking dispositions. It’s also based on Spearman’s Rho test results which indicated that there is a positive and significant correlation between creative thinking ability and disposition. Therefore, the students who have a higher score in creative thinking ability also have a higher score in creative thinking dispositions.

The results also follow the prior research result by Wardhani that there is an association between creative thinking ability and mathematical disposition through the Sylver model approach [26]. Reynaldi also found there is a correlation between creative thinking ability and mathematical disposition [27]. On the other hand, Sumarmo said that there is not an association between creative thinking ability and creative thinking disposition through Think-Talk-Write strategies [28]. These findings indicate that the existence of the association between mathematics ability and its affective aspect is not consistent. It depends on learning strategies.

4. Conclusion

Based on the discussion about the data analysis result, we can conclude that there is a significant correlation between creative thinking ability and creative thinking disposition. Creative thinking ability is directly proportional to creative thinking disposition. If creative thinking ability is higher, then creative thinking disposition is also higher. Otherwise, if creative thinking ability is lower, then creative thinking disposition is lower too. The correlation between creative thinking ability and creative thinking disposition exists at the middle level.

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