

IJER, 5 (1), 2020, 7-17

Students Math Creative Thinking Skill

Jonni Sitorus*

Badan Penelitian dan Pengembangan Provinsi Sumatera Utara, Jl. Sisingamangaraja No.198, Siti Rejo I, Medan, North Sumatra, Indonesia

Abstract

This research aims at describing the ability and level of the student's creative thinking. This is qualitative research. Operationally, this research was conducted with some steps, namely: giving a set of creative thinking test of 26 students to measure the ability and level of their creative thinking and choosing one student randomly from each student's personality type to be interviewed to search their cognitive knowledge. The results show that every student has a creative thinking ability, but the level of creative thinking varies. The category of student's creative thinking ability is "moderate or high." The student's creative thinking level is "very creative, creative, quite creative, or less creative." The student's cognitive knowledge is drawing, designing, ascertaining, dividing, reasoning, analogy, imagining, utilizing, solving, understanding, determining, mentioning, and using trial and error.

Keywords: Math, Creative, Thinking, Skill

1. Introduction

Creativity is a combination between the variables of intellectuality and personality (Amabile, 1996; Eysenck, 1993, Furnham et al., 2008). Creativity does not only refer to creative thinking ability, but also refers to other abilities as an impact from other cognitive functions (Silvia, 2008), but creative thinking ability is a main reason to research creativity (Williams et al., 1988; Santrock, 2003). Williams et al. (1988), cognitive traits of creative thinking ability are: fluency, flexibility, originality, elaboration, and many affective traits namely: curiosity, courage to take risks, challenged by plurality, and imaginative (Munandar, 1977; Treffinger, 1980). According to Liu et al., (2017), creative thinking ability is an ability to produce many creative ideas. Creative ideas are sources of creativity (Pannells & Claxton, 2008; Runco et al., 2014). Olson (1999), creative thinking is an individual ability based on its uniqueness to generate creative ideas.

Creative thinking ability refers to ability of solving the problems. According to Abraham & McComas (1999), divergent questions can increase and construct students' creativity. Divergent questions need more than 1 answer. They need high student's thinking level. Students must be able to remember some information. They must also implement other knowledge to describe, explore, and analyze a topic, situation or problem. Divergent questions (open-ended questions) are a set of

questions to require students to analyze, describe, hypothesize, solve, find, or evaluate. According to Livne, Livne, & Wight (2008), open-ended question can stimulate creativity, original thinking ability, and math innovation.

Isaksen et al (Grieshober, 2004) define creative thinking as a process of constructing ideas with some aspects of fluency, flexibility, novelty, elaboration (Martin, 2009), productivity, and benefits (Briggs & Davis, 2008). McGregor (2007), creative thinking is a new insight, approach, perspectives, or method (Martin, 2009) to solve problem. According to Sharp (Briggs & Davis, 2008), Novelty refers to a unique solving-problem strategy. Novelty is not idea really new, but new for students. When students find the solution from problem for the first time, so they have found something new, at least new for students themselves. Productivity refers to construction as possible as many ideas. Benefits refers to usefulness of ideas. Creative thinking has an impact for increasing students' confidence to solve new problems. A product is not categorized novel unless it is useful.

Harris (2000), there are 3 aspects of creative thinking ability, namely: success, efficiency, and coherence. Success refers to conformity of solution to solve problem; efficiency refers to practicality of strategy to solve problem; coherence refers to unity of ideas or solutions. Coherent ideas are well-organized, holistic, synergistic, and aesthetic ideas.

Silver (1997) provides indicators (fluency, flexibility & novelty) to evaluate students' creative thinking by

*) Corresponding Author.

E-mail: sitorus_jonni@yahoo.co.id

posing the problem and then solving it. The 3 components to evaluate students' math creative thinking are different and not bound to each other. Students with different ability and background have also different ability levels, and it can be caused by their different environment. Some students maybe meet the 3 components, but some students maybe only meet 1 or 2 components.

According to Munandar (1999), fluency refers to: 1) many ideas, many answers, many problem solvings, many questions; 2) many ways or methods to solve the problem; 3) always think more than 1 answer. Flexibility refers to: 1) able to construct variety of ideas, answers, questions; 2) able to see the problem from different viewpoint; 3) find many different answer alternatives; and 4) able to find new solving approach. Originality refers to: 1) able to find something novel; 2) think an unusual way to self-express; and 3) able to make an unusual combination. Based on the explanation above, the research questions are: 1) how is student's math creative thinking ability? and 2) how is process of getting student's creative ideas? For addressing the two questions above, the research goal is to find the students' math creative thinking ability and process of getting their creative ideas.

2. Method

This study is a qualitative research that aims at finding a phenomenon of math creative thinking ability of students and process of getting their creative ideas. Operationally, this study was conducted with some steps such as research initiation; data collection; data analysis; and data validation test.

a. Research Initiation

On research initiation step, researcher did 2 main works namely: choosing and determining school as research location, and designing research instruments (open ended test) for math creativity. To determine school as research location, researcher searched some information from school that has implemented creativity concept for math lesson by visiting some elementary schools; searching primary school database from the earlier relevant studies; or asking for some information from some colleagues. Sekolah Dasar Islam Terpadu Hikmathul Fadhillah was chosen as a research location because this school has met the criteria.

b. Data Collection and Analysis

Data was collected in 2 ways, namely test (quantitative data) and in depth interview (qualitative data). The Research question 1 needs qualitative and quantitative data, and research question 2 needs qualitative data.

Test was used to evaluate students' creative answers. Student's math creative thinking ability can be got by calculating the student's mean score without differing

the creative thinking indicator, then converted it into the mean value to see category of their math creative thinking ability based on Scale 5. Each true answer gets score 5. The way to calculate the mean score is (the total true answers x 5): 2 (number of questions), then converted into value. Nurkencana & Sumartana (1989) classified the mean value (MV) based on Scale 5, from "very low" ($0 \leq MV < 55$); "low" ($55 \leq MV < 65$); "enough" ($65 \leq MV < 80$); "high" ($80 \leq MV < 90$); and "very high" ($90 \leq MV \leq 100$).

Student math creative thinking ability is also analyzed based on 3 creative thinking indicators, namely fluency, refers to the number of true answer for two-dimensions drawing; flexibility, refers to the number of true answer for two-dimensions drawing and its pattern is different with two-dimensions drawing on the question sheets; novelty, refers to the number of true answer for unique two-dimensions drawing.

Category of students' math creative thinking level refers to Siswono's opinion (2004, 2005), namely: level 4 (very creative), student has more than 1 novel answer; level 3 (creative), student has only 1 novel answer; level 2 (enough), student has only more than 1 flexible answer; level 1 (less creative), student has only 1 flexible answer; and level 0 (not creative), student is unable to solve the problem.

Four of 26 students who attended test were chosen based on their creative thinking ability and level to be key informants to be interviewed. They are 1 very creative student, called Student 1; 1 creative student, called Student 2; 1 enough creative student, called Student 3; and 1 less creative student, called Student 4. Researcher interviewed them based on their answer sheet about how they got creative answers and ideas. Researcher also used tape recorder to record the interview results. The acquired data and information from the various data collection techniques were in complementing each other.

Qualitative data was analysed qualitatively. According to Glaser et al. (2010), data was analysed in 3 phases, namely data reduction, data presentation, conclusion or verification.

c. Data Validation Test

Data was validated in 3 ways, namely (1) data clarification by asking the students based on the previous data researchers got. If students did not do activity as shown on previous data, so data is invalid. It means, data cannot be used; (2) data verification by checking data from different sources, namely in depth interview results, tape recorder and students' answer sheet. If data does not contradict each other, so data is valid, however if data contradicts each other, researcher will review data. Some steps for reviewing data, namely: retesting students. According to students' test results, researcher redo in depth interview such as a previous

IJER, 5 (1), 2020, 7-17

data collection; and data revision by revising data if any mistake or contradiction.

d. Research Procedures

- 1) Researcher designed 2 open ended math questions based on creativity. The 2 questions are 1) divide a piece of rectangular-size F4 paper with a length of 21 cms and a width of 33 into 2 sections which have equal area. Give a variety of answer alternatives for unique and novel two-dimensions drawing; and 2) mall, parking place, flower garden and restaurant will be built on a plot of land which has a right triangle shape with a length of 100 meters and a width of 80. Determine and divide the right triangle into several unique and novel two-dimensions drawings for the places of mall, parking places, flower garden and restaurant. The total area from each two-dimensions drawing is equal with the area of a plot of land. Give a variety of answer alternatives for unique and novel two-dimensions drawing.
- 2) Researcher gave the questions for 26 students of one classroom who attended test to be answered creatively. Researcher emphasized to students to answer the questions by giving various, unique, and novel answers.
- 3) Researcher corrected all students' answers to calculate the mean score and value and analyze them to determine their math creative thinking ability.
- 4) Researcher sorted students' answers based on creative thinking indicator to determine their math creative thinking level
- 5) Researcher chose 4 of 26 students based on their creative thinking ability and level to be key informants to be interviewed about how they got creative answers and ideas.
- 6) After getting qualitative and quantitative data, researcher analyzed it and made a research article.

3. Result and Discussion

3.1. Student Math Creative Thinking Ability

Researcher calculated the mean value of students' math creative thinking ability without differing creative thinking indicator by converting the mean score into mean value. Researcher grouped students' math creative thinking ability based on Scale 5.

The mean value of students' math creative thinking ability fluctuates very much from the category "low" to "very high. Overall, the average is 74,62 with a category "enough". There are 5 students who got mean value under the overall average range and 11 students above the overall average range. It means that the number of students who got mean value above the overall average range is much more than the number of students who got mean value under the overall average range.

Here is students' math creative thinking ability based on creative thinking indicators on Table 1.

Table 1. Student Math Creative Thinking Ability based on Creative Thinking Indicators

No.	Creative thinking indicators	Overall average value	Category
1.	Fluency	77,69	Enough
2.	Flexibility	66,67	Enough
3.	Novelty	50,64	Very low

Student math creative thinking ability based on 3 creative thinking indicators (fluency, flexibility & novelty) decreases sequentially. They have different solving-problem difficulty level to find for students. It means that the solving-problem difficulty level from indicator of fluency, flexibility and novelty is sequentially more difficult. This solving-problem difficulty level has an impact to the number of novel answers that the students can give to be on the wane. The mean value of students' math creative thinking ability decreases if the solving-problem difficulty level is high.

The 26 students could give fluent, flexible and novel answers, but the number of answers for some students is different. Here is the number of students' answers for each question

This is the way to count the number of students' answers, for example from Question 1. A student divided a piece of rectangular-size F4 paper into 2 parts of rectangle; 2 parts of triangle; 2 parts of trapezium; 2 parts of polygon with zig-zag shapes; and 2 parts of polygon with circular shapes. From this example, she has 5 answer alternatives, namely rectangle, triangle, trapezium, and 2 polygons with zig-zag and circular shapes. The number of students' answers from Question 2 is also counted with the same way such as counting the number of students' answers from Question 1.

The number of fluent answers from her 5 answer alternatives is 1, namely rectangle. It is two-dimensions that has had previous drawing pattern and its drawing has same pattern with two-dimension drawing on question 1; the number of flexible answers is 2, namely triangle and trapezium. They are two-dimensions that have had previous drawing pattern and the drawing has not same pattern with two-dimension drawing on question 1; and the number of novel answers is 2, namely polygons in zig-zag and circular shapes. They are two-dimensions that have no previous drawing pattern and the drawing has not same pattern with two-dimension drawing on question 1.

IJER, 5 (1), 2020, 7-17

Researcher also describes students' math creative thinking level. Researcher grouped it by referring to Siswono opinion, as shown on Table 2.

Table 2. Student Math Creative Thinking Level for Each Question

Student Math Creative Thinking Level	Number of Students for Each Question	
	Question 1	Question 2
Level 4 (very creative) Criteria: more than 1 novel answer	12	10
Level 3 (creative) Criteria: only 1 novel answer	14	15
Level 2 (enough creative) Criteria: more than 1 flexible answer	0	0
Level 1 (less creative) Criteria: only 1 flexible answer	0	1
Level 0 (not creative) Criteria: no answer	0	0
Total	26	26

Overall, the 26 students have various math creative thinking level, from the level of “very creative, creative, and less creative”. There is a difference of students' math creative thinking level from Question 1 and Question 2. Some students are at least in category of “creative” for Question 1, but one student is in category of “less creative” for Question 2. This difference is caused of the solving-problem difficulty level of 2 questions. The solving-problem difficulty level of Question 2 is more difficult than Question 1. It means that the solving-problem difficulty level has an impact to creative thinking level.

For searching data and information about how students got their math creative thinking ability, researcher chose 4 students based on their creative thinking ability and level to be key informants to be interviewed. They are Student 1 (less creative student), Student 2 (enough creative student), Student 3 (creative student) and Student 4 (very creative student).

Based on interview results with Student 4 about how she got her math creative thinking ability, that she did not really understand the two-dimensions concept. She never studied it yet before. Her creativity and imagination ability appeared suddenly at that time. She could see the linkages between two-dimensions with the other two-dimensions. She divided a rectangle (Question 1) into: 2 parts of right triangle; 2 parts of right-angled trapezium; and 2 parts of polygon in zig-zag shape. She only relied her imagination ability to draw polygon in zig-zag shape as unique and novel answer (interview & tape recorder results). The other students (Student 1,

Student 2 & Student 3) did the same things with what Student 4 had done to get math creative thinking ability, such as using imagination ability, able to see the linkages between two-dimensions with the other two-dimensions, able to divide a rectangle into 2 parts of two-dimensions drawing with unique and novel shapes (interview & tape recorder results).

Based on interview results with Student 3 about how she proved that 2 parts of two-dimensions drawing have same area as required on Question 1, she said that the 2 parts of two-dimensions drawing have same shape, pattern, and size, so the area must be same. Her knowledge for drawing polygon with unique and novel shapes flowed as it did. She used a trial-error system to draw polygon as unique and novel answers. She also used her math intuition ability to draw polygon with unique and novel shapes (interview & tape recorder results). The other students (Student 1, Student 2 & Student 4) said the same things to prove that 2 parts of two-dimensions drawing have same area as Student 3 said. They also used their math intuition abilities and trial-error system to draw polygon as unique and novel answers (interview & tape recorder results).

Based on interview results with Student 2 about how she got math creative thinking ability, that he divided a triangle (Question 2) into small parts of two-dimensions drawing, such as 2 triangle drawings for parking place and restaurant locations, trapezium drawing for mall location, circle drawing for flower garden location, and polygon as an empty land that surrounds the flower garden. He drew polygon (pentagon) with irregular shape. Pentagon with irregular shape is an unusul two-dimensions drawing which has a unique and novel shape, and has no special pattern (interview, answer sheet & tape recorder results).

Based on interview results with Student 2 about how to determine the area of each part of two-dimensions drawing that he drew, that he determined the two-dimensions area by using some steps. *First*, he determined or counted the size (height, length, width) each part of two-dimensions drawing which the size must fit with the size of two-dimensions drawing on Question 2. He used the direct proportion concept to count the size of height or width of triangle by comparing a triangle with small size with another triangle with big size. *Second*, she counted the area of each part of two-dimensions drawing by using suitable area formula, for example: the area formula of triangle = $\frac{1}{2} \times \text{height} \times \text{width}$; the area formula of rectangle = length x width; the area formula of circle = πr^2 ; etc; and *third*, he totalized all area of part of two-dimensions drawing which the area must be same with the area of triangle drawing as required on Question 2. The other students (Student 1, Student 3 & Student 4) did the same things to determine the area of each part of two-

IJER, 5 (1), 2020, 7-17

dimensions drawing that they drew (interview, answer sheet & tape recorder results).

Based on interview results with Student 2, he used aesthetic value to draw two-dimensions. He connected the two-dimensions drawing with other discipline (Art subject). The circle drawing as a flower garden location is equipped with flower drawings in its inside to add the beauty of two-dimensions drawing, as if all objects in its inside look real. Trapezium drawing as a mall location is equipped with some window drawings; right triangle drawing as a parking place location is equipped with some vehicle drawings; and right triangle drawing as a restaurant location is equipped with some table and chair drawings. these all can add the aesthetic value of two-dimensions drawings. The other students (Student 1, Student 3 & Student 4) did the same things to add the aesthetic value of two-dimensions drawings (interview, answer sheet & tape recorder results).

Based on interview results with Student 1, she used her math intuition knowledge to solve Question 2. She used her strong instinct and conviction as incarnation of her math intuition ability to find the unique and novel answers. She divided a triangle drawing (Question 2) into some parts of two-dimensions drawings by only relying her imagination ability or her ability flowed as it did. She generated and used her previous experience to solve Question 2. The other students (Student 2, Student 3 & Student 4) did the same things to solve Question 2 (interview, answer sheet & tape recorder results).

Based on interview, answer sheet & tape recorder results as described above, researcher can summarize students' math creative thinking ability qualitatively on Table 3.

Table 3. Student Math Creative Thinking Ability Qualitatively

No.	Students' math creative thinking ability (two-dimensions material)
1.	Ability of drawing two-dimensions <ul style="list-style-type: none"> - Dividing two-dimensions drawing into some parts of two-dimensions drawing with various, unique, and novel shapes, such as: right triangle, right-angled trapezium, rectangle, circle, semicircular, polygon, & pentagon - Drawing two-dimensions with unusual and irregular shape, and the two-dimensions have no previous patterns.
2.	Ability of connecting two-dimensions with other disciplines <ul style="list-style-type: none"> - Connecting two-dimensions with Art subject as a local subject at

No.	Students' math creative thinking ability (two-dimensions material)
	school <ul style="list-style-type: none"> - Connecting interdisciplinary science among two-dimensions - Integrating two-dimensions with all objects in the inside and around each location - Integrating, adjusting, and completing some different objects on two-dimensions drawing
3.	Ability of giving aesthetic value for two-dimensions drawing <ul style="list-style-type: none"> - Making all objects in inside and around each two-dimensions drawing meaningful - Coloring two-dimensions and its objects in the inside.
4.	Ability of determining the area of two-dimensions <ul style="list-style-type: none"> - Writing and using the formula of the area of two-dimensions correctly - Determining the size of length, width, height, or radius of two-dimensions correctly - Calculating the area of two-dimensions correctly
5.	Math intuition ability <ul style="list-style-type: none"> - Utilizing experience, both daily and learning experiences to find creative ideas - Using strong conscience and instinct to find creative ideas - Imagining to find creative ideas

Based on Table 3, math creative thinking ability is not the only one ability to find creative ideas, but there are other abilities integrated with math creative thinking ability itself to find creative and inovative answers. They are ability of: drawing two-dimensions, connecting two-dimensions with other disciplines, giving aesthetic value for two-dimensions drawing, determining the area of two-dimensions, and math intuition.

3.2. Process of Getting Student Math Creative Ideas

For searching data and information about how students got their math creative ideas, researcher interviewed 4 students as key informants in this research. Based on interview results with all informants (Student 4, Student 3, Student 2, Student 1) about how they got their math creative ideas to solve 2 questions, that they did 3 thinking activities, namely: analyzing pieces of math ideas to find a main math idea, connecting math ideas with other discipline, and solving

the problem. They analyzed the characteristic, component, connection, and pattern of pieces of math ideas and synthesize pieces of math ideas to find main math ideas. They connected math ideas with daily lives and synergize math ideas with other school subjects. They solved the problem by bringing out ideas, then establish ideas to be realized (interview & tape recorder results).

Here are samples of process of generating a trapezium from 2 different two-dimensions, namely: triangle and rectangle. Based on interview results with Student 4 about how she got her math creative ideas, , that the tapezium drawing is the results of analysis and combination from 2 ideas to be a main idea.

3.3. Data Validation Test

Student cognitive knowledge on Table 1 is still need to be validated by clarifying and verifying them. The clarification and verification results are valid.

First, the students' ability of drawing unique and novel two-dimensions as research finding is in accordance with the opinion of Habiba et al. (2015). They said that Novelty in the problem solving refers to diversity of answers, uniqueness or novelty of answers. Uniqueness or novelty of answers must be adapted to student's knowledge and development level. Silver (1997) stated that Novelty is different answers but true and no specific patterns.

Choi (2004) stated that Novelty is individual's new experiences where the novelty level is an incompatibility function between the past and present experiences. In this research context, the past experiences refer to students' learning experiences in the past time before conducting the research. The present experiences refer to students' learning experiences when the research was conducted. The cognitive knowledge and creative thinking ability of students are different in these two conditions. Here it is the cause of incompatibility of students' learning experiences between before and when research was conducted, which can show a gap of creative thinking ability itself. It means that to evaluate the novelty of students' answers ought to consider and compare the previous and present conditions, and Novelty is not general for all conditions.

According to Briggs & Davis (2008), Novelty is not idea really new, but new for students. Polygon (pentagon) as students' novel answers is not two-dimensions drawing really new shapes. Idea of polygon (pentagon) drawing is not idea really new from students, but pentagon drawing as students' answer is the newest or novelest one of other students' answers in one classroom. That is why that polygon (pentagon) drawing has the category of unique and novel shape. The uniqueness and novelty of students' answers is at least new for students themselves.

The two-dimensions drawing with unique and novel shapes is productivity of math creativity as students' answers which is constructed by as possible as many ideas. The impact of learning two-dimensions for students refers to the usefulness of answers from their findings. An answer is categorized as a new and creative product, if the product is useful for them.

According to Munandar (1998) that: 1) creativity is an ability of making a new combination based on data, information, or other ones. For example: a polygon drawing with irregular shapes is constructed from some different two-dimensions. It has a specific unique and novelty; 2) creativity is an ability of finding many answer alternatives from a problem. It refers to the quantity, efficiency, and diversity of answer; and 3) creativity is an ability of producing the original answers. Munandar also stated that creative thinking ability has indicators of fluency, flexibility, productivity (Martin, 2009), originality, novelty, and elaboration (Grieshober, 2004). Creative thinking is an acquisition of new insight, approach, perspectives, or way to understand math problem (McGregor, 2007).

Ability of drawing two-dimensions is constructed from students' math creative ideas (Grieshober, 2004). This research finding is also in accordance with the opinions Sembiring et al. (2008) and Gravemeijer (1994). They stated that learning math can create students to have a set of concepts of math ideas that impacts to their cognitive ability. Students get new knowledge for themselves to draw many unique and novel two-dimensions. The new knowledge comes from a set of variety of experiences to solve math problems.

Every student can produce unique and novel two-dimensions drawing as his/her answer, but some students have different creative thinking level. This research finding is in accordance with the opinion Solso (1995) which stated that every individual has a potential to think creatively, but every individual has different creative thinking level. Individual's creative thinking level is a continuum from the lowest to the highest level which can be categorized.

Second, ability of connecting two-dimensions with other disciplines as a research finding is in accordance with NCTM (2000). Math is not partially taught for students, but math has a connection with the others (Saminanto & Kartono, 2015; Swedosh & Clark, 1997). Students should connect the previous math concepts with the next ones. Connection ability is one of student's math basic abilities in America, China, Indonesia, etc. It is adapted from the one of the characteristics of realistics math education, namely linkages/connections. Connection is a student's ability to connect the concepts, algorithm, math material (Bell, 1981; Mhlolo et al., 2012), or math with other disciplines. Connection ability is one of main goals to learn math, including the

learning-math goal in math curriculum in Indonesia. Math is not a partitioned ability from a set of topic, although it is often taught partially for some math branches. Math is an integrated science. Math has a connected concept, principle, and skills. Learning math is an effort to develop student's connection ability, which is focused on: 1) focus to use math connection among math ideas; 2) understand the linkages of math ideas with the others to understand math comprehensively; and 3) focus to use math in out of math context.

Math connection ability is also focused to 1) connection of conceptual and procedural knowledge; 2) connecting math with other curriculum areas; 3) applying math to the real daily lives; 4) math as an integrated union; 5) using math thinking ability to solve the problem in other subjects; 6) understand connection among math topics; and 7) understand various representation for the sama concepts (Berlin & White, 1999). Ulet (2000) stated that math connection indicators are: 1) solving problem by using graphics, numerics, algebraic, and verbal representations; 2) using concepts and procedures for new situation; 3) understand relationship among math topics; and 4) expand math ideas.

Math connection ability is an important ability for students to have it. There are only some students to be able to connect math with other discipline. Students are able to identify the math concepts integrated with the real problems, but only fewer students who are able to understand and describe what the math connection (Bergeson, 2000). Most students get trouble to apply math in the real daily lives (Jenning & Dunne, 1999). Connecting math ideas for students' daily lives is important to make a meaningful learning-math (Soejadi, 2006; Gravemeijer, 1994). Students need to get training about how connect math with the other discipline (Henvel-Panhuizen, 2000). The training of math connection ability can develop and increase students' math learning and motivation (Banihashemi, 2003) by implementing the discuss process as learning-math activities in the classroom (Stylianides & Stylianides, 2007). Students are not passive receivers of ready-made mathematics (Hadi & Fauzan, 2003), but they are active receivers who are able to develop their math potential for themselves.

The math connection is be a beauty of math itself (Cuoco et al., 1996). Connecting math can bring out the new technique and method to solve the math problem. Students will feel the math beauty when they are able to connect math with the others. There are some math concepts connected with the others, namely: triangle congruence concept, comparison/ratio, geometry, algebra, trigonometry, table representation, gradients, and line equations.

Third, ability of giving aesthetic value for two-dimensions drawing as a research finding is in accordance with the opinion Iswadi (2001). Two-dimensions drawing is part of learning-math material at school which is unable to be partialized from aesthetic sciences. Ability of drawing two-dimension is a ability to construct geometry model, sketch the image, label the picture, draw two-dimensions based the characters of two-dimensions , construct two-dimensions with available two-dimensions. Students need reasoning and math manipulation to generalize, visualize, describe and compare two-dimensions in various positions (Imawati, 2008; Nurdalilah, 2014; Sembiring, 2014). The ability of drawing is important for students to build students' sustainable knowledge to improve their creativity. Most creative and inovative people use their reasoning power to create something novel. They can see something from different viewpoint. They can also change their reasoning results into other representations to create something novelty.

According to Suyanto (2005), the benefits of aesthetic value integrated with learning-math (two-dimensions material) are 1) as a learning media to express themselves. Students can express their feeling through art activities to draw two-dimensions; 2) developing their ability of giving aesthetic value; 3) developing their motoric ability; 4) developing their coordination ability; 5) developing their perception to math; and 6) developing their creativity and reasoning power.

Fourth, ability of determining the area of two-dimensions is the evidence of students' understanding for using the true area formula of two-dimensions. According to de Walle (2008), students often make a mistake to determine the area of two-dimensions by using the incorrect formula. They also often make a mistakes to conceptualize the height, width, length, or radius of two-dimensions. They must learn math comprehensively to construct their new knowledge from their previous experiences and knowledge (Bosse & Bahr, 2008). Learn math comprehensively is important to enable them to solve the new math problem in he future.

Fifth, math intuition ability as a research finding is in accordance with the previous research results. Math creative thinking is a combination between logical and divergent thinking based on intuition with the indicators of fluency, flexibility, and novelty. (Pehkonen, 1997; Krutetskii, 1976; Haylock, 1997; Silver, 1997). Dallas & Gaier (1970) stated that ability of intuition is one of the characters of creative individual. Bishop (Pehkonen, 1997) stated that an individual needs 2 math thinking abilities to solve math creative problem, namely: creative thinking ability identified with intuition ability,

IJER, 5 (1), 2020, 7-17

and analytic thinking ability identified with logical thinking ability.

An individual uses an intuition ability when an individual does metacognition (Schoenfeld, 1992). There are 3 ways to do a metacognition in the learning math process, namely: 1) beliefs and intuition, refers to math ideas to solve math problems and how the math ideas construct way or method to solve the math problem; 2) knowledge about thinking process, refers to how accurate for thinking process; and 3) self-awareness (self-regulation), refers to how accurate to solve the math problems.

According to Hurlock (1973), that creativity concept is more to act of producing than end results themselves. Act of producing is an activity process from self-individual with some ability dimensions, namely: intellect, intuition, emotion, sensory, behavior, which can be learnt and regenerated through the education program and creativity guidance at school (Torrance, 1984).

Sixth, connecting math with the others as one of the processes of getting students' math creative ideas as this research finding is in accordance with the opinion Evans (1991), that stated that creative thinking is an ability of finding new relationships, seeing the problem from new perspectives, and construct new combination (Hwang et al., 2007; Treffinger, 2005; Alexander, 2007) from available concepts in the inside of thinking. Leng & Hoo (1997) stated that creative thinking is the ability to see a new way that can result a new combination.

Getting creative ideas to meet the creative thinking ability to solve math problem as this research finding is in accordance with the opinion Nakin (2003) that stated that creative thinking is a process of synthesizing various available concepts to solve the problem. Krutetski (Park, 2004) stated that creative thinking is an ability to find solution flexibly. The problem solving is a process to ask students to find new ways or method to solve the new problem (Hudojo, 2003; Krulik & Rudnick, 1995).

Mace, et al., (2002) stated that thinking activities for creative thinking process are to develop ideas by rearranging math creativity ideas; identify the possibilities of developing ideas; and evaluate them through analogy and metaphor.

4. Conclusion

Math creative thinking ability is not the only one ability to find creative ideas, but there are other abilities integrated with math creative thinking ability itself to find creative and inovative answers. They are ability of: drawing two-dimensions, connecting two-dimensions with other disciplines, giving aesthetic value for two-dimensions drawing, determining the area of two-dimensions, and math intuition. There are 3 thinking

activities in the process of getting math creative ideas, namely: analyzing pieces of math ideas to find a main math idea, connecting math ideas with other discipline, and solving the problem.

The suggestion is that teacher should train students to: draw the two dimensions which have flat, flexible and unique shapes and can calculate the area; utilize previous knowledge and experience to solve problems as a child intuition process; and integrate mathematics with other disciplines.

Reference

- Abraham, L., & McComas, W.F. (1999). *Asking more effective questions*. Ressler School of Education. https://uwaterloo.ca/centre-for-teaching-excellence/sites/ca.centre-for-teaching-excellence/files/uploads/files/asking_better_questions.pdf.
- Alexander, K. L. (2007). Effects instruction in creative problem solving on cognition, creativity, and satisfaction among ninth grade students in an introduction to world agricultural science and technology course. *Dissertation*. Texas Tech University.
- Amabile, T.M. (1996). *Creativity in context*. Boulder, Colorado: Westview Press.
- Banihashemi, S.S.A. (2003). Connection of old and new mathematics on works of islamic mathematician with a look to role of history of mathematics on education of mathematics role of history of mathematics on education of mathematics trisection of triangle. *Informing Science*, (June).
- Bell, A.W. (1981). *Diagnosing students misconception*, Melbourne: The Australian Mathematic Teacher.
- Bergeson, T. (2000). *Teaching and learning mathematics*, Washington: State Superintendent of Public Instruction.
- Berlin, D.F. & White, A.L. (1999). Mathematics and science together: Establishing the relationship for the 21 st century classroom. *International conference on mathematics into the 21st century: Societal challenges, issues, and approaches*, pp.57–62.
- Bossé, Michael J. & Bahr, Damon L. (2008). The state of balance between procedural knowledge and conceptual understanding in mathematics teacher education. Department of Mathematics and Science Education: *Journal of Mathematical Behavior*, Vol. 17, No. 3, 317-327.
- Briggs, M., & Davis, S. (2008). *Creative teaching: Mathematics in the early years and primary classroom*. London: Routledge.
- Choi, J.N. (2004). Individual and contextual predictors of creative performance: The mediating role of

IJER, 5 (1), 2020, 7-17

- psychological processes. *Creativity Research Journal*, 16, 187–199.
- Cuoco, A.A., Goldenberg, P.E. & Mark, J., (1996). Habits of minds: An organizing principle for mathematics curriculum. *Journal of Mathematical Behavior*, 15, pp.375–402.
- Dallas, Marie; & Gaier, Eugene L. (1970). Identification of creativity: The individual. *Psychological Bulletin*, 73(1), 55-73.
- Evans, J.R. (1991). *Creative thinking in the decision and mangement sciences*. Dallas: Collage Division South- Western Publishing Co.
- Eysenck, H. J. (1993). Creativity and personality: Suggestions for a theory. *Psychological Inquiry*, 4, 147–178.
- Furnham, A., Batey, M., Anand, K., & Manfield, J. (2008). Personality, hypomania, intelligence and creativity. *Personality and Individual Differences*, 44, 1060–1069.
- Gravemeijer, K., (1994). *Developing realistic mathematics education*, Utrecht: Freudenthal Institute.
- Grieshober, Wiliam. E. (2004). *Continuing a dictionary of creative term and definitions*. Buffalo State College: The International Center for Studies in Creativity.
- Habiba, Fonda Essa, Sunardi, S., & Trapsilasiwi S. Dinawati. (2015). Analisis keterampilan metakognisi berpikir kreatif dalam menyelesaikan masalah matematika pokok bahasan segiempat peserta didik kelas akselerasi di MTs Negeri 2 Jember. *JURNAL EDUKASI UNEJ* 2015, II (2): 16-21.
- Hadi, S. & Fauzan, A., (2003). Mengapa PMRI ? Dalam Buletin PMRI (Pendidikan matematika realistik Indonesia). *Buletin PMRI (Pendidikan Matematika Realistik Indonesia*, 1(Juni), p.2003.
- Harris, P. (2000). *The work of the imagination*. Oxford: Blackwell.
- Haylock, D. (1997). Recognising mathematical creativity in schoolchildren. *ZDM*, 29(3), 68-74.
- Heuvel-panhuizen, M. Van Den, (2000). The didactical use of models in realistic. *Educational Studies in Mathematics*, 54, pp.9–35.
- Hudojo, H. (2003). *Common text book pengembangan kurikulum dan pembelajaran matematika*. Bandung: JICA Universitas Pendidikan Indonesia (UPI).
- Hurlock, B.E. (1973). Adolescent development, (Edisi, 4).
- Hwang, W.Y., Chen, N.S., Dung, J.J.,& Yang, Y.L. (2007). Multiple representation skills and creativity effects on mathematical problem solving using a multimedia whiteboard system. *International Forum of Educational Technology & Society Journals*. Volume 10(2), 191-212.
- Imawati, Anik. (2008). Peningkatan penalaran dan komunikasi matematika siswa dengan menggunakan model STAD berbasis quantum teaching berbantuan LKS pada materi pokok relasi dan fungsi kelas VIII SMP N 22 Semarang. *Skripsi*. Semarang: Program Sarjana UNNES.
- Iswadi, Djoko. (2001). *Geometri ruang*. Universitas Negeri Yogyakarta: Jurusan Pendidikan Matematika FMIPA.
- Jenning, Sue & Dunne, R. (1999). *Math Stories, Real Stories, Real-Life Stories*. www.ex.ac.uk/telematics/T3/maths/mathfram.html.
- Krulik, S & Rudnick, J.A. (1995). *The new sourcebook for teaching reasoning and problem solving in elementary school*. Needham Heights, Massachusetts: Allyn & Bacon.
- Krutetskii, V. A. (1976). *The psychology of mathematical abilities in schoolchildren*. Chicago, USA: The University of Chicago Press.
- Leng, Y.L & Hoo, C.T. (1997). Explaining the thinking, learning styles, and cognition constructs. *The Mathematics Educator*, vol. 2(1), 113-127.
- Liu, W., Pan. Y., Luo. X., Wanga, L., & Pang, W. (2017). Active procrastination and creative ideation: The mediating role of creative self-efficacy. *Personality and Individual Differences*, 119 (2017) 227–229. <http://dx.doi.org/10.1016/j.paid.2017.07.033>.
- Livne, N. L, Livne, O. E., & Wight, C. A. (2008). *Enhancing mathematical creativity through multiple solutions to open-ended problems online*. [file:///C:/Users/Windows10/Downloads/ENHANCING MATHEMATICAL CREATIVITY THROUGH MULTIPLE.pdf](file:///C:/Users/Windows10/Downloads/ENHANCING%20MATHEMATICAL%20CREATIVITY%20THROUGH%20MULTIPLE.pdf).
- Mace, M. & Ward, T. (2002). Modeling the creative process: A grounded theory analysis of creativity in the domain of art making. *Creativity Research Journal*, 14, pp.179–192.
- Martin, Pamela N. (2009). Societal transformation and reference services in the academic library: theoretical foundations for re-envisioning reference. *Library Philosophy and Practice* 2009 (May).
- McGregor, S.L.T. (2007). International journal of consumer studies: Decade review (1997- 2006). *International Journal of Consumer Studies*, 31(1), 2-18.
- Mhlolo, M.K., Venkat, H. & Schfer, M. (2012). The nature and quality of the mathematical connections teachers make. *Pythagoras*, 33(1), pp.1–9.

IJER, 5 (1), 2020, 7-17

- Munandar, S.C. Utami. (1998). *Pengembangan kreativitas anak berbakat*. Jakarta: PT Rineka Cipta.
- Munandar, S.C. Utami. (1999). *Kreativitas dan keberbakatan*. Jakarta: Gramedia Pustaka Utama.
- Munandar, S.C.U. (1977). *Creativity and education*, Jakarta: Fakultas Psikologi UI.
- Nakin, J.B.N. (2003). Creativity and divergent thinking in geometry education. *Dissertation*. University of South Africa.
- NCTM. (2000). *Principles and standards for school mathematics*, Reston: NCTM. Available at: http://www.nctm.org/uploadedFiles/Math_Standards/12752_exec_pssm.pdf.
- NCTM. (2000). *Principles and standards for school mathematics*. United States of America: The National Council of Teachers of Mathematics, Inc.
- Nurdalilah; Syahputra, Edi; & Armanto, Dian. (2014). Perbedaan kemampuan penalaran matematika dan pemecahan masalah pada pembelajaran berbasis masalah dan pembelajaran konvensional di SMA Negeri 1 Kualah Selatan. *Jurnal Pendidikan Matematika PARADIKMA*, Vol 6(2), hlm. 109 – 119.
- Olson, J.A. (1999). What academic librarians should know about creative thinking. *The Journal of Academic Librarianship*, Vol. 25 No. 5, pp. 383-389.
- Pannells, T. C., & Claxton, A. F. (2008). Happiness, creative ideation, and locus of control. *Creativity Research Journal*, 20(1), 67–71.
- Park, H. (2004). The effects of divergent production activities with math inquiry and think aloud of students with math difficulty. *Dissertation*. Texas A&M.
- Pehkonen, E. (1997). The state-of-art in mathematical creativity. *International Reviews on Mathematical Education*, 29, 63–66. Retrieved March 10, 2003, from <http://www.fiz-karlsruhe.de/fiz/publications/zdm/adm97>.
- Pehkonen, E. (1997). The state-of-art in mathematical creativity. *ZDM*. Vol 29 (3). Electronic Edition 63-67.
- Pehkonen, E. (1997). The state-of-art in mathematical creativity. Dalam *zentralblatt für didaktik der mathematik (ZDM)*. *The International Journal on Mathematics Education*. [Online]. Vol 97(3), 63 – 67. Tersedia: <http://www.emis.de/journals/ZDM/zdm973a1.pdf>. [13 Desember 2008].
- Runco, M. A., Walczyk, J. J., Acar, S., Cowger, E. L., Simundson, M., & Tripp, S. (2014). The incremental validity of a short form of the ideational behavior scale and usefulness of distractor, contraindicative, and lie scales. *The Journal of Creative Behavior*, 48(3), 185–197.
- Saminanto & Kartono, (2015). Analysis of mathematical connection ability in linear equation with one variable based on connectivity theory. *International Journal of Education and Research*, 3(4), pp.259–270.
- Santrock, J.W. (2003). *Psychology* (7th Ed.). New York: McGraw-Hill.
- Schoenfeld, A.H. (1992). *Learning to think mathematically: problem solving, metacognition, and sense-making mathematics*, California: Graduate School of Education, University of California.
- Sembiring, Amalia, V. (2014). Hubungan antara tingkat penalaran moral dan kecurangan akademis pada mahasiswa Universitas Andalas. *Laporan Penelitian*. Padang: FK PSI Universitas Andalas.
- Sembiring, Robert K., Hadi, Sutarto, & Dolk, Maarten. (2008). Reforming mathematics learning in Indonesian classrooms through RME. *ZDM Mathematics Education* (2008) 40:927–939, DOI 10.1007/s11858-008-0125-9.
- Silver, E.A. (1997). Fostering creativity through instruction rich in mathematical problem solving and thinking in problem posing. <http://www.fiz.karlsruhe.de/fiz/publications/zdm> ZDM Volum 29 (June 1997) Number 3. *Electronic Edition* ISSN 1615-679X.
- Silvia, P. J. (2008). Another look at creativity and intelligence. Exploring higherorder models and probable confounds. *Personality and Individual Differences*, 44, 1012–1021. doi:10.1016/j.paid.2007.10.027.
- Siswono, T.T. (2004). *Pendekatan pembelajaran matematika*. Jakarta: Depdiknas.
- Siswono, T.T., & Kurniawati. (2005). Identifikasi proses berpikir kreatif siswa dalam pengajuan masalah matematika dengan informasi berupa gambar: Penerapan model Wallas. *MATEMATIKA. Jurnal Matematika atau Pembelajarannya* 11(1) april 2005 ISSN: 0852- 7792.
- Soedjadi, R. (2006). Inti dasar-dasar pendidikan matematika realistik indonesia. *Jurnal Pendidikan Matematika*, 1(2), pp.1–10.
- Solso, R. L. (1995). *Cognitive psychology* (4th ed.). Boston: Allyn & Bacon, Inc.
- Stylianides, A.J. & Stylianides, G.J. (2007). Learning mathematics with understanding: A critical consideration of the learning principle in the principles and standards for school mathematics. *The Montana Mathematics Enthusiast*, 4(1), pp.103–114.
- Suyanto, Slamet. (2005). *Dasar-dasar pendidikan anak usia dini*. Yogyakarta: Hikayat Publishing.

IJER, 5 (1), 2020, 7-17

- Swedosh, P. & Clark, J. (1997). Mathematical misconceptions -- can we eliminate them? *Merga 20 - Aotearoa*, pp.492-499.
- Torrance, E.P. (1984). *Mentor relationships: How they aid creative achievement, endure, change, and die*, Buffalo: NY: Bearly.
- Treffinger, D.J. (1980). Encouraging creative learning for the gifted and talented. , p.1980.
- Treffinger, D.J. (2005). Creative problem solving: The history, development, and implications for gifted education and talent development. *The Evolution of CPS in Gifted Education: Gifted Child Quarterly*. Vol. 49, No 4, 343-353.
- Ulet. (2000). *High School mathematics I & II, sourcebook on practical work for teacher trainers*. Quezon City: SMEMDP.
- Van de Walle, John. (2008). *Elementary and middle school mathematics*. Alih Bahasa Suyono. Jakarta: Erlangga.
- Williams, J.M.G.; Watts, Fraser N.; MacLeod, Colin; & Mathews, Andrew. (1988). Cognitive psychology and emotional disorders.