Creative thinking level of visual-spatial students on geometry HOTS problems

A N Aini[1]**, M Mukhlis**[1]**, A M Annizar**[1]**, M H D Jakaria**[1]**, D D Septiadi**[1]

[1]State Institute for Islamic Studies of Jember, Jember Indonesia

Email: afifah.nur07@gmail.com

Abstract. The objective of this study is to describe student's creative thinking level. Creative thinking is a mental activity to find a new idea or a variety of solutions. The criteria for creative thinking are fluency, flexibility, and novelty. The subjects were eleventh grade students who had visual- spatial intelligence. The level of creative thinking analyzed based on components of creative thinking that the subject met on geometry HOTS problems. Students are given a questionnaire to find out their type of intelligence. Then, students are given open-ended questions. Based on the analysis of students answer, visual-spatial students show a higher level of creative thinking. This indicates that visual-spatial students have better creative thinking skills in learning mathematics, especially on geometry.

1. Introduction

Creativity is one of the objectives of schools education. Developed a taxonomy that revised Bloom's taxonomy [8]. Dimensions of cognitive processes based on revised Bloom's Taxonomy consist of remembering, understanding, applying, analyzing, evaluating, and creating. It is understood that creating occupies the highest level in this system. Create means the ability to put elements together to form a related whole and functionally rearrange those elements in a new product.

Although every student has creative potential, the level of creativity of each student is different. The level of creative thinking of students is influenced by many things, one of which is the type of intelligence. Certain types of intelligence are often associated with students' mathematical abilities. As well as mathematical logical intelligence that is associated with algebraic and numerical abilities, as well as spatial-visual intelligence that is associated with geometry abilities. The research aims to determine the level of creative thinking of students with the type of visual-spatial intelligence. Students with this type of intelligence are given problems to find out the level of creative thinking skills.

Mathematics taught in schools to make students skilled at solving problems. Problems are defined as assignments that students must complete without routine procedures to solve. In the process of problem-solving, students gain experience, use knowledge and skills. Students can use a variety of ways and obtain a variety of answers. This is an indicator of creative thinking skills. Familiarizing students with creative thinking can stimulate the growth of creativity, which is an important requirement in the modern world. Creative thinking is defined as a mental activity to find a new idea, find a variety of solutions to a problem. The criteria for creative thinking are fluency, flexibility, and novelty [15].

Creativity is a complex construct and most commonly expressed through a broad range of intelligence including linguistic, musical, mathematical, spatial, kinesthetic, interpersonal, intrapersonal and naturalistic [5]. Creative thinking defined as a combination of logical thinking and divergent thinking which is based on intuition but has a conscious aim. When a student applying creative thinking in a practical problem-solving situation, divergent thinking produces many ideas. It explains that creative thinking requires logical and intuitive thinking to generate ideas. Hence, in creative thinking, two parts of the brain are needed. The balance between logic and intuition is essential. When using too much logic, creative ideas will be ignored. Therefore, for creative thinking is needed the freedom of thought, is not under the control or pressure [10].

Creativity in mathematics is more focused on aspects of the process. This argument explains that creativity in mathematics more precise termed as mathematical creative thinking. Creativity is closely related to deep, flexible knowledge in content domains; is often associated with long periods of work and reflection rather than rapid, exceptional insight; and is susceptible to instructional and experiential influences. The contemporary view of creativity also suggests that persons who are creative in a domain appear to possess a creative disposition or orientation toward their activity in that domain. That is, creative activity results from an inclination to think and behave creatively [13].

Torrance states four components in the process of creative thinking: (1) fluency; the ability to generate a number of ideas, (2) flexibility; the ability to produce diverse ideas, and (3) novelty, the character of a unique way of thinking [9]. Creative thinking also can be interpreted as a mental activity that is used by someone to develop ideas or new ideas. The process of creative thinking is the steps which include synthesizing ideas, building an idea, then planning the application of ideas and applying those ideas to generate new ideas [15].

Thus, it can be said that creative thinking is someone's ability to create new ideas in dealing with problems. To be categorized creatively, ideas must be varied, different from ideas that are already common or unique, and can be explained in detail, is appropriate, and useful.

Creativity is a product of one's creative thinking. Creative thinking is a process that is used when we bring in/come up with a new idea. This was done by combining ideas that were previously owned [15]. Creative thinking skills have a significant influence on learning mathematics in school. There are three components of creative thinking including:

a. fluency: the ability of students to provide diverse and correct solutions.
b. flexibility: the ability of students to answer a problem with several different answers.
c. novelty: students' ability to present various solutions or unusual solution done by students at the level of knowledge; solutions are called novelty if they appear different and do not follow a certain pattern [15].

The characteristics of the levels of creative thinking as shown in Table 1 contained a different primary aspect for each level. The difference is in the creative thinking aspects that consisted of flexibility, novelty, and fluency in mathematical problem solving [16].

Tabel 1. Level of Creative Thinking

Level	Characteristic of creative thinking level
Level 4 Very Creative	Student is able to solve a problem with more than one solution and can represent another way to solve it. One solution fulfills originality (novelty).
Level 3 Creative	Student is able to solve a problem with more than one solution, but he/she cannot represent another way to solve it. One solution fulfills originality (novelty). An alternative characteristic, he/she can represent another way to solve a problem, but he/she) cannot make a novelty solution.
Level 2 Quite Creative	Student is able to solve a problem with one original solution however it does not fulfill fluency or not flexibility. Or, he/she can represent

Level 1 Almost Not Creative	Student is able to solve a problem with more than one solution but cannot represent another way to solve it. The solution does not fulfill originality (novelty).
Level 0 Not Creative	Student cannot solve a problem with more than one solution and cannot represent another way to solve it. Solutions do not fulfill originality (novelty), fluency and flexibility.

Students' creative thinking skills in the process of learning mathematics can be influenced by many factors, including intelligence. Thinking always influenced by creativity and intellectual abilities of a person, when a student is considered to be creative, he has minimum levels of intelligence. So it was found that there is relationship between creativity and intelligence [2].

Intelligence is some individual capacities to carry out a goal, think rationally and interact with their environment. In solving a problem, a person's knowledge can be applied properly through the assistance of intelligence (Dalal & Rani, 2013). To be called intelligence, an ability must meet eight criteria: (1) it is isolated in a particular part of the brain, (2) that ability is independent, (3) contains a special operating unit, (4) has its developmental history, (5) relates to the history of evolution in the past, (6) support for psychological tasks, (7) support for psychometric discoveries, and (8) can be symbolized [5].

Three variables that influence one's thinking skills are: cognitive variables, environmental variables, and personality variables. Intelligence is one of the cognitive variables [4]. According to him, someone who has creative thinking skills must have a high level of intelligence, but a person with a high level of intelligence is not necessarily creative. Intelligence is an element of the creative process, and the effects of intelligence and creativity work together.

Level of intelligence commonly expressed by certain values, the type of intelligence students have is also likely to make an impact. Intelligence possessed by humans, there are eight types which are referred as multiple intelligences [5]. Someone might be better at one type of intelligence and less good at another type of intelligence.

Visual-spatial learners are individuals who think in pictures rather than in words. They have a different brain organization than auditory-sequential learners. They learn better visually than auditorially. They are whole-part learners who need to see the big picture first before they learn the details. Visual-spatial students may have difficulty with easy tasks but show amazing ability with difficult, complex tasks. They are systems thinkers who can orchestrate large amounts of information from different domains, but they often miss the details. They tend to be organizationally impaired and unconscious about time. They are often gifted creatively, technologically, mathematically or emotionally [14].

Geometry is important for several reasons. It offers us a way to interpret and reflect on our physical environment. It can serve as a tool for the study of other topics in mathematics and science. As important is spatial thinking, which supports geometry and creative thought in all mathematics. Given their importance, it is essential that geometry and spatial sense receive greater attention in instruction and research [3].

Higher Order Thinking Skill (HOTS) is a real-life based assessment of everyday life, but in practice, the students are having trouble completing the HOTS issue. Learning difficulty is also influenced by personality type. Based on the fact that the real difference one can see from a person is behavior [7].

Assessment of the 2013 Curriculum adapts international standard assessment models, hopefully, helps students in increasing their level of thinking ability, because high-level thinking of learners can be encouraged to think broadly and deeply about the subject matter. The Bloom Revision Taxonomy is used to measure high-level thinking skills (HOTS), the dimensions of the cognitive process is used to measure high-level thinking skills by category of analyzing, evaluate and create [8].

High-level thinking ability, it is shown that based on the Trends in International Mathematics and Science Study (TIMSS) survey in 2011 the achievement of Indonesian mathematics students ranked 38th out of 42 countries with an average score of 386. By the Organization for Economic Co-operation and Development (OECD) in 2015 using the Program for International Student Assessment (PISA) test that Indonesia's mathematical achievement ranks 69 out of 76 countries that follow PISA. Thus, it appears that there is still a low level of mathematics achievement in the ability to think high levels of Indonesian high school students at the International level. The instilment of high-level thinking ability should have been begun by schools in Indonesia order to meet the demands of the 21st century. This is

in line with the characteristics of the 21st-century community's skills according to the partnership of 21st-century skills that identify students in the 21st century should be able to develop the competitive skills required in the 21st century that are focused on the development of HOTS [7].

2. Methodology

This research was conducted among 127 students in grade 11 during their mathematics and geometry courses in a high school and the application of research had two stages. The research took place in a public high school. The first part of the study consists of a questionnaire of multiple intelligences. Then five visual-spatial students chosen as subjects of this research. They completed three geometry problems to find out the level of creative thinking.

The results of the study were analyzed based on the answers written by the subjects on the answer sheet. If the information from the answers written by students is felt to be lacking, the researcher conducts direct interviews to get more in-depth information. In addition to tests and interviews, the researchers also conducted direct observations of the process of working on the tests and daily mathematics learning activities carried out by students in the class.

3. Results

Based on the initial questionnaire given to 127 students, it was found that the percentage of students with each of their multiple intelligences was presented in the following figure.
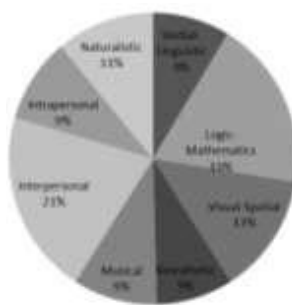

Figure 1. Percentage of Multiple Intelligene Type

Subject S1 is at Level 3 for all question. He met components fluency, flexibility, and novelty. Subject S2 is at Level 4 for the first problem. He can present several different solutions, variously. While for the second and third problem he is at Level 3. Subject S3 is at Level 4 for problem number 1 and 2 and Level 3 for third question. Subject S4 is at Level 4 for problem number 1 and 2. While for the third problem he is at Level 3. Subject S5 is at Level 3 for problem number 1, 2, and 3.

4. Discussion

Among 17 students with the type of visual-spatial intelligence, 5 were chosen to be the research subjects. They were given HOTS geometry questions to find out their creative thinking skills. The results of the analysis of the solution presented by the subject, it is known that the subject S1 can meet the components of fluency and flexibility for problem number 1. He can present several different solutions, but the steps for completion tend to be the same. S1 subjects can show solutions that meet novelty. Thus, subject S1 is at Level 3. While for question number 2, subject S1 presents several different solutions with different completion steps, but none meets the novelty, so it is said that it

meets Level 3. While for question number 3, S1 subjects can present several different answers but with relatively similar completion steps. one of the solutions he wrote meets the novelty component so that it can be said that he is at Level 3.

Subject S2 can meet the components of fluency, flexibility, and novelty for the first problem. She can present several different solutions, variously. Thus, she is at Level 4. While for the second problem, she presents several different solutions with different completion steps, but none meets the novelty, so it is said that it meets Level 3. For the third problem, subjects S2 can present several different answers but relatively similar completion steps. One of the solutions she wrote meets the novelty component so that it can be said that he is at Level 3.

Subject S3 can meet the components of fluency, flexibility, and novelty for problem number 1. She can present several different solutions, but the steps for completion tend to be the same. She can show solutions that meet novelty. Thus, subject S3 is at Level 4. While for question number 2, subject S3 presents several different solutions with different completion steps and meets novelty, so it is said that it meets Level 4. While for question number 3, S3 subjects can present several different answers but with relatively similar completion steps. Although one of the solutions meets the novelty component so that it can be said that he is at Level 3.

Subject S4 can meet the components of fluency, flexibility, and novelty for problem number 1. He can present several different solutions, variously. She can show solutions that meet novelty. Thus, subject S4 is at Level 4. While for the second problem, subject S4 presents several different solutions with different completion steps and meets novelty, so it is said that it meets Level 4. While for the third problem, he can present several different answers with relatively similar completion steps. Although one of the solutions meets the novelty component so that it can be said that he is at Level 3.

Subject S5 can meet the components of fluency and flexibility for problem number 1. He can present several different solutions, variously. However she can not show solutions that meet novelty. Thus, subject S1 is at Level 3. While for question number 2, subject S1 presents several different solutions with different completion steps, but none meets the novelty, so it is said that it meets Level

3. While for question number 3, S1 subjects can present several different answers variously. One of the solutions he wrote meets the novelty component so that it can be said that he is at Level 3.

In general, students with the type of visual-spatial intelligence are at level 3 or level 4. This shows that they are quite creative in solving geometry problems. This is similar to the results of research by Gezel and Sener (2009). The results of their study show that spatial ability (three-dimensional thinking) improves students' understanding of symbols, shapes, tables, and figures. Besides, it assists students in comprehending drawings easily, commenting on the visualized information, creating contexts among different concepts easily, generalizing complex concepts, and thinking in different ways. Accordingly, spatial ability plays a crucial role to be successful in mathematics, specifically in geometry, for the reason that the field is based on visualization.

The results of the another research, students gain in geometric and spatial skills and show pronounced benefits in the areas of arithmetic and writing readiness. Students are better prepared for all school tasks when they gain the thinking tools and representational competence of geometric and spatial sense [3].

5. Conclusion

Finally, this research suggests that the importance of creative thinking in education should be realized by the authorities and this point should be a very important issue on the educator's agenda. Further, more scientific researches on the use and development of creative thinking should be conducted and relevant resources for the research should be allocated.

Based on this research, it is known that visual-spatial subjects can reach Level 3 or Level 4. Subjects with the visual-spatial intelligence have a good mastery of spatial problems of navigation, visualization of objects from different angles and space, faces or scenes recognition, or to notice fine details. Therefore, the subject can present a variety of solutions to the given mathematical problems.

A visual-spatial students are able to solve problems related to the perspective of 3-dimensional space correctly. It would be better for mathematics learning designed by the teacher to stimulate students' creative thinking skills. This can be done by giving HOTS assignments that enable students to solve them with various strategies; or provide a variety of solutions. Teachers are expected to familiarize students with math problem solving; as well as familiarize students to think creatively by presenting the open ended questions.

References
[1] Anderson J 2009 Mathematics Curriculum Development and the Role of Problem Solving *ACSA Conf.*
[2] Dalal S and Rani G 2013 Relationship of Creativity and Intelligence of Senior Secondary Students *International Journal of Humanities and Social Science Invention* **2** 70-74
[3] Douglas C 1998 *Geometric and Spatial Thinking in Young Children* (Arlington: National science Education)
[4] Eysenck H J 1994 *The Measurement of Creativity* (Cambridge: The MIT Press)
[5] Gardner H 1983 *Frames of Mind* (New York: Basic Books)
[6] Guzel and Sener 2009 High School Students' Spatial Ability And Creativity In Geometry *Procedia Social and Behavioral Sciences* **1** 1763–1766
[7] Karimah, Kusmayadi and Pramudya. 2018 Analysis of Difficulties In Mathematics Learning on Students With Guardian Personality Type in Problem-Solving HOTS Geometry Test *Journal of Physics: Conf. Series*
[8] Krathwohl D R 2002 *A Revision of Bloom's Taxonomy: An Overview*. Theory Into Practice **41** 212-218
[9] Leikin R 2009 Exploring Mathematical Creativity Using Multiple Solution Tasks *Journal of Creativity in Mathematics and the Education of Gifted Students* 129–145
[10] Maharani H R 2014 Creative Thinking In Mathematics: Are We Able to Solve Mathematical Problems in A Variety of Way? *ICMSE Conf. Proc.*
[11] Munandar U 2009 *Developing Gifted Child Creativity* (Jakarta: Rineka Cipta)
[12] Ramdani Y 2014 Scientific Debate Learning to Improve Students' Creative Thinking Abilities. *Mimbar* **30** 1-10
[13] Silver E A 1997 *Fostering Creativity Through Instruction Rich in Mathematical Problem Solving and Problem Posing*
[14] Silverman L K 1999 The Visual-Spatial Learner: An Introduction *Soundview School Dolphin News* 6-7.
[15]Siswono T Y E 2007 *Theoretical Construction of Students Creative Thinking Level in Mathematics.*
[16] Siswono T Y E 2010 Leveling Students' Creative Thinking In Solving And Posing Mathematical Problem *IndoMS J M E* **1** 17-40
[17] Siswono T Y E 2011 *Level of Student's Creative Thinking in Classroom Mathematics.* Educational Research and Review **6** 548-553
[18] Sternberg J R 2004 *Handbook of Creativity* (Cambridge: Cambridge University Press)
[19] Williams G 2002 *Identifying Tasks That Promote Creative Thinking in Mathematics: a Tool. Mathematical Education Research Group of Australasia Conference* (New Zealand)