Creative thinking ability based on learning styles reviewed from mathematical communication skills

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Abstract: This study aims to obtain the explanation of mathematical creative thinking skills based on visual and kinesthetic learning styles from mathematical communication skills. The subject of this study is a collection of scores on mathematical creative thinking abilities, learning styles and mathematical communication skills of 26 students of the Laboratory High School UPI, tenth-grade (14 students of visual learning styles and 12 students of kinesthetic learning styles). This study is a comparative causal study. Analysis of data using ANCOVA because in this study involved one dependent variable namely the ability of interval-scale creativity and two independent variables namely category-scale learning style and interval-scale mathematical communication skills as well as covariates. The results of the study show that:1) there is a linear relationship between mathematical communication skills and creative thinking abilities, which that the assumption of ANCOVA is fulfilled;2) there are differences in creative thinking skills between students who have a visual learning style with students kinesthetic learning styles without regard to mathematical communication skills, and based on the average creative thinking abilities of with kinesthetic learning styles higher than visual learning styles;3) there is a simultaneous influence between mathematical communication skills and learning styles towards creative thinking abilities.

1. Introduction

One of the abilities that contribute to the success of one's life is the ability of creativity. This capability is needed especially in facing the challenges of the future and the era of globalization and the sophisticated communication technology that is growing so rapidly. Likewise, this capability is very important because in everyday life everyone is always faced with various problems that must be solved and demands creativity to find solutions to the problems they face.

The 2013 curriculum emphasizes the importance of developing student creativity. It is stated by Permendikbud No. 103 of 2014 concerning the standard learning process which states that "the learning process in each primary and secondary education unit must be interactive, inspiring, fun, challenging, and motivating students to actively participate, and provide sufficient space for initiatives, creativity, and independence in accordance with the talents, interests and physical and psychological development of students ". The Deputy Minister of Education and Culture's exposure to education on the implications of the 2013 Curriculum in Jakarta on January 14, 2014, also stated that learning must support the development of students’ creativity. Learning mathematics without an
emphasize on creativity would eliminate the opportunity to develop their talents [1]. Based on the explanation, of course, there is a demand for teachers to develop creativity in the learning they do.

Regarding the measurement of mathematical creativity [2, 3] reported that the aspect of creativity measured in solving mathematical problems was fluency, flexibility, and originality. Tribs aspect of creativity is measured, namely: fluency, flexibility, and novelty (originality) [4]. Fluency is a fluent thinker who can produce many ideas [5], possibilities and possible approaches to finding solutions to problems. Flexibility is the ability to give different responses to a question [6]. Whereas Originality is a mathematical response that must be original, rare and following mathematical problems [7]. To see a lot of ideas conveyed by students, of course, students must be given an open problem, considering open problems are a problem that allows more than one solution.

No less important ability is also possessed by students namely mathematical communication skills, communication skills in learning mathematics need to be considered, this is due to communication mathematics that can organize and consolidate students' mathematical thinking both orally and in writing [8]. If students have communication skills, they will certainly bring students to a deep understanding of mathematics about the mathematical concepts learned. The aim to be achieved in mathematics learning is to provide the widest opportunity for students to develop and integrate communication skills through oral and written, modeling speaking, writing, talking, drawing, and presenting what has been learned [9]. The same is stated in the objectives formulated by the National Council of Teachers of Mathematics (2000) and the 2013 curriculum.

There are two important reasons why communication in mathematics needs to be developed among students. First, mathematics as a language means that mathematics can be used as a tool to communicate various ideas clearly, precisely and concisely. Second, mathematics as a social activity means that mathematics can be used as a social activity in learning, such as interactions between students and students [10]. Furthermore, children, important mathematics is used as their second language. If learning mathematics only remembers formulas or memorizes formulas rather than communicating mathematical ideas, then mathematics becomes a difficult domain to pass [11]. Therefore communication skills in mathematics need to be developed to accelerate students' mathematical understanding.

The form of communication used by the teacher is very influential in the success of the teaching-learning process. In mathematics learning, a form of multidirectional communication can help students sharpen their communication skills, convey, and express their mathematical ideas. Communication is the process of conveying meaning in the form of ideas or information from someone to others. Communication mathematics is the process of expressing ideas and understanding of mathematics verbally, visually, and in writing, using numbers, symbols, images, graphics, diagrams, and words [12]. Indicators of students' abilities in mathematical communication in mathematics learning [13] include drawing, mathematical expression, and writing texts. (a) The ability to drawing includes the ability of students to express mathematical ideas into pictures, diagrams, or graphics; (b) The ability of mathematical expressions includes the ability to make mathematical models and; (c) The ability to write (texts) in the form of the ability to provide explanations and reasons in the correct language. Based on the explanation above, Mathematical Communication is a person's ability to use vocabulary, notation and mathematical structures to express and understand mathematical ideas and relationships. The indicators of mathematical communication skills are (1) Written Text; (2) Drawing and (3) Mathematical expressions.

The ability to be important for creative thinking and mathematical communication is mastered by students, while findings in the field that both these capabilities are still low and most learners are accustomed to rote learning activities form without accompanied the development of creative thinking and mathematical communication. The teaching pattern that has been used by teachers has not been able to help students solve problems in the form of problems, activate students in learning, motivate students to express their ideas and opinions, and even students are still reluctant to ask teachers if they do not understand the material presented by the teacher. Besides that, the teacher is always pursued by the target time to complete each subject matter without regard to the competencies of the students.

Every student has a personal uniqueness that is different from the others. Each student is different in the level of learning speed, and learning style. This difference in ways of learning shows the easiest
way for students to absorb information during learning. The easiest and fastest way for a person to learn is known as a learning style [14]. The key to success in learning and working is knowing the unique learning or working style of each person, accepting one's strengths and weaknesses and adjusting personal preferences as much as possible in every situation of learning, study and work [15]. Thus, style learning is the key to student success in learning.

There are three types of learning styles, namely visual, auditory and kinesthetic. Visual learning style: this type of learning style is learning by seeing, Children who have this learning style are informed by having eye contact with what is learned. Auditory learning style: this type of learning style is learning by listening, does not require eye contact, but quite optimizes hearing only while Kinesthetic learning: learning style types are learning how to move, work and touching, so that he does not like to sit for long to listen to lectures only He tends to move, touch, and do [16]. Every child has more than one learning style that is used to achieve his learning goals. If a teacher can identify trends in student learning styles, this will be very useful in developing the teaching and learning process. Based on the explanation above, learning styles are the easiest and fastest way for a person to learn. The study in this study is visual learning style and kinesthetic learning style.

2. Method
Research questions lead to descriptive quantitative research. This study was a Comparative Causal study is the ex post facto study aimed at comparing two or more groups with events has occurred so that no more treatment is needed. Where in this study, researchers wanted to see the achievement of differences in the influence of creative thinking skills based on learning styles in terms of mathematical communication skills.

Based on the research problem formulation, the formulation of the first research question requires researchers to see a linear relationship between mathematical communication skills and the ability to think creatively to see whether or not the assumption of ANACOVA is fulfilled. While the second research question requires researchers to see the achievement of differences in the influence of mathematical creative thinking skills based on learning styles by paying attention to students' mathematical communication skills. And in the third research question to see simultaneously whether there are differences in mathematical communication skills and visual and kinesthetic learning styles towards students' creative thinking abilities.

The variables in this study include independent variables, covariate variables, and dependent variables. The independent variables in this study are mathematical communication skills and learning styles (visual learning styles and kinesthetic learning styles), and where mathematical communication skills are also seen as covariate variables. While the dependent variable is the ability to think creatively mathematically.

3. Result and Discussion
Data analysis is using ANACOVA with SPSS-23 as a tool to analyze the data. The use of ANACOVA is because in this study involved one dependent variable, namely the ability of interval-scale mathematical creativity and two independent variables namely category-scale learning style and interval-scale mathematical communication skills and simultaneously as covariate variables. To answer the first, second and third research hypotheses. Data score Ability Creative Thinking Skills (ACTS) Students with Learning Styles (LS) in terms of visual and kinesthetic Ability Mathematical Communications (AMC) seen in Table 1.
Table 1. CBC Score Data for Students with LS Visual and Kinesthetic reviewed from AMC Learning Style

| No | Learning Style Visual |  | Learning Style Kinesthetic |  |
|----|------------------------|---|---------------------------|---|
|    | AMC (X) | ACTS (Y) | AMC (X) | ACTS (Y) |
| 1  | 80      | 84      | 75      | 80      |
| 2  | 85      | 84      | 60      | 77      |
| 3  | 70      | 78      | 60      | 80      |
| 4  | 50      | 60      | 70      | 83      |
| 5  | 75      | 70      | 85      | 87      |
| 6  | 60      | 78      | 70      | 83      |
| 7  | 60      | 78      | 60      | 78      |
| 8  | 65      | 70      | 70      | 78      |
| 9  | 75      | 78      | 70      | 82      |
| 10 | 50      | 60      | 75      | 87      |
| 11 | 80      | 85      | 60      | 79      |
| 12 | 75      | 78      | 70      | 78      |
| 13 | 60      | 79      |         |         |
| 14 | 65      | 77      |         |         |
| 𝑥  | 67,857  | 75,642  | 68.75   | 81      |

Based on Table 1 above, taking into account the research objectives to obtain a comprehensive picture of mathematical creative thinking skills based on visual and kinesthetic learning styles associated with mathematical communication skills, the analysis of data using ANACOVA with the help of SPSS-23 results in Table 2.

Table 2. Tests of Between Mathematical ACTS and Learning Style in terms of AMC

| Tests of Between-Subjects Effects |
|----------------------------------|
| Dependent Variable: Creative Thinking Ability |

| Source                   | Type III Sum of Squares | df | Mean Square | F     | Sig.  |
|--------------------------|-------------------------|----|-------------|-------|-------|
| Corrected Model          | 705,010 ^a              | 2  | 352,505     | 18,783| .000  |
| Intercept                | 974,131                 | 1  | 974,131     | 51,906| .000  |
| Mathematical Communication| 519,570                 | 1  | 519,570     | 27,685| .000  |
| Learn Style              | 156,517                 | 1  | 156,517     | 8,340 | .008  |
| Error                    | 431,644                 | 23 | 18,767      |       |       |
| Total                    | 159789,000              | 26 |             |       |       |
| Corrected Total          | 1136,654                | 25 |             |       |       |

a. R Squared = .620 (Adjusted R Squared = .587)

In Table 2 above, it can be seen that the number of significance for the covariate variables namely mathematical communication skills is 0.000. Because the significance of covariance is less than 0.05, it can be concluded that at the 95% confidence level it can be said that there is a linear relationship between mathematical communication skills and students' mathematical creative thinking abilities. This statement indicates that Ananova's assumptions have been fulfilled. So that the research hypothesis is accepted which means that: there is a linear relationship between mathematical communication skills and the ability to think creatively.

To find out the learning style variable by paying attention to the significance value for the learning style of 0.008 and because the value is far below 0.05 then H₀ is rejected. So that it can be concluded that without regard to mathematical communication skills, at a 95% confidence level there is a difference between students who have visual learning styles and kinesthetic learning styles towards students' creative thinking abilities. So that the research hypothesis is accepted which means that: there
are differences in creative thinking skills between students who have a visual learning style with students kinesthetic learning styles regardless of mathematical communication skills.

To know simultaneously the differences in students' mathematical communication skills and visual learning styles with kinesthetic learning styles towards students' creative thinking abilities can be seen from the numbers of significance in the Corrected Model section. It appears that the significant number is 0,000. Because the significance value is far below 0.05 then at the 95% confidence level it can be concluded that the research hypothesis is accepted, which means that: there are differences simultaneously mathematical communication skills and visual and kinesthetic learning styles towards mathematical creative thinking abilities.

By paying attention to the average level of the group's visual and kinesthetic learning styles in mathematical communication skills and students' creative thinking abilities, the average visual learning style of students mathematical communication skills is 67,857 while the average student's visual learning style of creative thinking communication skills is 75,642. This means that, by paying attention to students 'learning styles, students' creative thinking abilities in visual learning styles are superior to those of mathematical communication skills of students who have a visual learning style. While the average kinesthetic learning style of students mathematical communication skills of 68, 75 and the average kinesthetic learning style of students creative thinking skills of 81. This means that by paying attention to student learning styles students' creative thinking abilities kinesthetic learning styles are superior compared to Mathematical communication skills of students who get kinesthetic learning styles.

This is in line with several previous research studies that say that the ability to think creatively through mathematical ideas and discoveries is needed in a globalizing world so that people can survive. To achieve this, there is a need for teachers and prospective mathematics teachers who will guide students who have creative ideas, make discoveries and produce new ideas in an educational environment where individuals are educated. The habit of creative individuals is characterized by (a) look for ways to see problems that other people don't look for, (b) take risks that people are afraid to take, (c) have the courage to defy the crowd and to stand up for their own beliefs, and (d) seek to overcome the obstacles and their views that other people give to, among other things [17, 18, 19].

The results of this study indicate that the tendency to think creatively from prospective mathematics teachers is in a group consisting of a "good" range in the total score section [20]. The results of the study investigating the causal relationship between mathematical creativity and mathematical intelligence with a sample of four hundred thirty-nine grade 8 students, ages ranging from 11 to 14 years the results showed that there was a mutually reinforcing relationship between mathematical intelligence and mathematical creativity where mathematical intelligence caused as mathematical creativity and vice versa [21].

So to build students' creative knowledge, it must be considered the student's learning style and teacher's ability to manage to learn in the classroom. Because each student has a personal uniqueness that is different from the others. Each student is different in the level of learning speed, and learning style. This difference in ways of learning shows the easiest way for students to absorb information during learning. The key to success in learning is knowing learning styles from each. If a teacher can identify trends in student learning styles, this will be very useful in developing the teaching and learning process. This is in line with the results of this study, which shows that the creativity of students can be developed by paying attention to student learning styles at the beginning of learning. And besides that, the teacher must also be creative, where creative teachers are individuals who have self-confidence, are open to communication and innovation, in guiding students [22]. So that a math teacher who can produce a different solution to each problem, tries to make the lesson more fun by using his creativity. So that students' creativity appears in the learning process, where creativity is the ability of individuals to produce things that are appropriate and new.

Previous studies have suggested that the development of internet and communication technology has revolutionized the changing content and methods of education, a teacher must develop more creative teaching methods to teach new generation students. Previous research proves that fostering students' creative thinking can significantly influence creativity and student achievement. The approach to the web-based era revolutionary changed the media of teaching creative thinking by using
a sample of 186 universities in Taiwan preceded by a 4-month teaching program in this study. Research findings show (1) remarkable positive effect of web-based teaching creative thinking on creativity. creativity (2) a significant effect noted on learning outcomes, and (3) a significant positive effect of web-based teaching creative thinking on the learning outcomes [23].

Besides that, influencing creativity is the learning style of a student who learns visual, auditory and kinesthetic styles separately. The findings obtained each student has a personal uniqueness that is different from the others. Each student is different in the level of learning speed, and learning style. This difference in ways of learning shows the easiest way for students to absorb information during learning. The key to success in learning is knowing learning styles from each [24].

By train communication skills, creative ideas of students are expected to be delivered friends through oral and written communication, has is in line with the research, a da two important reasons why communication in mathematics needs to be developed among students. First, mathematics as a language means that mathematics can be used as a tool to communicate various ideas clearly, precisely and concisely. Second, mathematics as a social activity means that mathematics can be used as a social activity in learning, such as interactions between students and students [10]. So by paying attention to mathematical communication skills, students' learning styles are expected to increase students' creative thinking skills.

4. Conclusion
Based on the results and discussion of research on mathematical thinking skills based on visual learning styles and kinesthetic learning styles in terms of mathematical communication skills, it was concluded that: 1) there is a linear relationship between mathematical communication skills and creative thinking abilities, which means that the assumption of ANACOVA is fulfilled; 2) there are differences in creative thinking skills between students who have a visual learning style with students kinesthetic learning styles without regard to mathematical communication skills, and based on the average students' creative thinking abilities that are kinesthetic learning styles higher than visual learning styles; 3) there is a simultaneous influence between mathematical communication skills and learning styles on mathematical creative thinking abilities.

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References
[1] Mann E L 2009 The Search for Mathematical Creativity: Identifying Creative Potential in Middle School Students Creativity Research Journal. 21 4 338
[2] Kattou M, Christou C, and Pitta-Pantazi D 2016 Characteristics of the Creative Person in Mathematics. In G. B. Moneta & J. Rogaten (Eds.), Psychology of Creativity: Cognitive, Emotional, and Social Processes pp 99–124 (Hauppauge, New York: Nova Science Pub Inc)
[3] Mann E L 2006 Creativity: The Essence of Mathematics. Journal for the Education of the Gifted 30 2 236
[4] Silver E A 1997 Fostering Creativity through Instruction Rich in Mathematical Problem Solving and Problem Posing ZDM the International Journal on Mathematics Education 29 3 75
[5] Mann E, Chamberlin S A, and Graefe A K 2017 The Prominence of Affect in Creativity: Expanding the Conception of Creativity in Mathematical Problem Solving. In R. Leikin & B. Sriraman (Eds.) Creativity and Giftedness: Interdisciplinary Perspectives from Mathematics and Beyond pp 57–76 (Switzerland: Springer)
[6] Vidal R V V 2005 Creativity for Operational Researchers. Investigação Operacional (Portugal, 25 1
[7] Lev M and Leikin R 2017 The Interplay between Excellence in School Mathematics and General Giftedness: Focusing on Mathematical Creativity. In R. Leikin & B. Sriraman (Eds)
Creativity and Giftedness: Interdisciplinary Perspectives from Mathematics and Beyond pp 225–238 (Switzerland: Springer)

[8] Saragih S 2007 Develop Logical Thinking Skills and Communicate Mathematics in Junior High School Students Through Realistic Math Approvals Dissertation not published (Bandung: UPI Bandung Postgraduate Program)

[9] Collins W, Linda D, Patricia F M, Arthur C, Howard, Kay M C, David D, Molina, Beatrice M H, Jack O, Ronald S, Pelfrey, Jack P, Barbara S, and Patricia S W 1998 Mathematics: Applications and Connections (New York: Glencoe/McGraw Hill)

[10] Dewi I 2008 Reading Students’ Thoughts in Learning Mathematics. Jurnal Pendidikan Matematika Paradigma 11

[11] Baroody A J 1993 Problem Solving, Reasoning, and Communicating, K-8. Helping Children Think Mathematically (New York: Merrill, an Inprint of Macmillan Publishing, Company)

[12] Ontario Ministry of Education 2005a Student Success Program: Grades 7 to 12 Provincial Report of Board Reported Data on the Nine Key Indicators of Success for 2003-04 and 2004-05 Unpublished Internal draft Report November 29, 2005.

[13] National Council of Teachers of Mathematics (NCTM) 1989 Curriculum and Evaluation Standards for School Mathematics (Reston VA: Authu)

[14] Hamzah B U 2010 New Orientation in the psychology of Students Who Have Learning Styles (Jakarta: Bumi Aksara)

[15] Prashign B 2007 The Power of Learning Styles: Memicu Anak Melejitkan Prestasi dengan Mengenali Gaya Belajarnya (Bandung: Kaifa)

[16] De P, Bobbi, and Mike H 2011 Quantum Learning: Membiasakan Belajar Nyaman dan Menyenangkan (Bandung: Kaifa)

[17] Sternberg R J 2017 School Mathematics as a Creative Enterprise. ZDM Mathematics Education 49 7

[18] Kaufman J C 2016 Creativity 101 (2nd edn) (New York: Springer)

[19] Sternberg R J 2015 Teaching for creativity: The sounds of silence. Psychology of Aesthetics, Creativity, and the Arts 9 2 115

[20] Cenberci S 2018 the Investigation of the Creative Thinking Tendency of Prospective Mathematics Teachers in Terms of Different Variables Journal of Education and Training Studies 6 9

[21] Tyagi T K 2017 Mathematical Intelligence and Mathematical Creativity: A Causal Relationship Creativity Research Journal 29 2 212

[22] Aslan N and Cansever B A 2009 The Primary School Teachers” Attitudes for Creativity in Education TUBAV Science Journal 2 3 333

[23] Cheng-Shih L 2016 Effects of Web-Based Creative Thinking Teaching on Students’ Creativity and Learning Outcome Eurasia Journal of Mathematics, Science & Technology Education 12 6

[24] Goodchild S & Grevholm B 2009 An Exploratory Study of Mathematics Test Results: What is the Gender Effect? International Journal of Science and Mathematics Education 7 1 161