Does gender affect the mathematics creativity of junior high school students?

S D A Permatasari, Budiyono and H Pratiwi

Master Program of Mathematics Education, Universitas Sebelas Maret, Jl. Ir. Sutami No. 36 A, Surakarta, Indonesia.

E-mail: siska.dyahayu94@gmail.com

Abstract. Mathematics learning in the 21st century is a learning that emphasizes the importance of development in 4 aspects (4C), one of them is creativity. Mathematical creativity is students' skill to solve a problem with several strategies to reach different answers in certain tasks which are useful in developing mathematical reasoning. Relating to this context, nowadays, the issues of gender in education have been concern, that education must treat male and female students as equal. This research used one-way ANOVA to analyze the differences between the mathematical creativity between male and female students in junior high school. The research method used was quantitative descriptive. The sample of this research was 56 students of SMP Batik Surakarta who were taken by random sampling method. The results found that male and female students did not have differences in the ability of mathematical creativity. The insignificant difference can only be seen from their average scores. Female students are superior to male in the indicators of fluency, flexibility, and elaboration, but not in the indicator of originality.

1. Introduction

Currently, world civilization has entered the twenty-first century. One of the challenges faced in education is the development of human resources who have creativity. In the past, creativity was always associated with literature and art, but now doing meaningful science is also considered as creativity [1]. Mathematical creativity comes from more than strong basic knowledge. It stems from the ability to break away from a stable mindset, look at problems from the outside and apply mathematical knowledge in seeing possibilities [2-4]. One challenging task is in interpreting the notions of mathematical creativity and its characteristics because there is no specific definition of mathematical creativity that is agreed upon by many people [5]. Mathematical creativity is the skill to formulate problems in new styles, find ways and solutions, and find methods of solutions to unusual problems. One way to develop students' authentic thinking is to provide open-ended questions that require students' mathematical creativity in answering these questions and allowing more than one answer [6, 7].

Furthermore, mathematical creativity plays an important role in advanced mathematical thinking [8]. This research is in line with Sriraman's research [9] which revealed that mathematical creativity explains the overall development of mathematics. Instead of being a source of development, mathematical creativity as a field was not well explored in mathematics and mathematics education in the world. On the other hand, Poincare [10] described that mathematical creativity referred to the ability to construct mathematical alternatives leading to success. Additionally, Haylock [3] classified mathematical creativity in two types: the ability to overcome obstacle conditions of mathematical problem solving;
and the ability to produce various kinds of products in mathematical situations. Furthermore, Saito [11] argued that creativity in a school context referred to the ability to produce new valuable things, and valuable things assessed by group members while the students were coping with the problems.

Moreover, mathematical creativity is defined as the ability to represent aspects of fluency, flexibility, originality, and elaboration [12, 13]. It is including a) fluency is related to the students ability to produce many answers or ideas that are relevant from a given problem, b) flexibility is associated with the ability of students to generate different ideas, able to change the system or approach, and be able to resolve the problem with the different direction of thinking from a problem, c) originality is the ability of students to try the approach in a way or method of an unusual or unique based on the ideas from the students themselves, d) elaboration is the student's ability to redefine a problem or situation and itemize in detail the steps of a problem given. The aspects uniqueness (originality) and detail (elaboration) are encapsulated into aspects of novelty in creative thinking that demonstrates the ability of students to solve problems. So, it can be concluded that mathematical creativity is students' ability to think in solving problems by different, various, and new methods that defined as the ability reflecting aspects of fluency, flexibility, originality, and elaboration. Thus, encouraging students' creativity needs to be given an open-minded atmosphere and opportunities for students to express different opinions, to ask questions freely, and to give students the right to choose learning resources and methods freely [14].

Measuring students' mathematical creativity is considered as one of the important things in assessment, especially because it is very valuable in today's society and must be developed in every individual [15, 16]. However, between individuals and groups, there may be differences in mathematical creativity and these differences require more knowledge to understand the cause. One of the differences that can be identified from creativity is gender differences. There may be differences in creativity between males and females because of gender differences are related to biological or social influences. Moreover, Stephens [17] explained that the importance of researching creativity depends on the socio-cultural differences between males and females, social and cultural differences are one of the things that can influence the development of students' creativity.

Some empirical research have been published not specifically discussing gender differences in mathematical creativity, but creativity in other forms [16, 18-21]. One of them is linguistic creativity like the research conducted by Kousoulas [20] which examined gender differences in divergent thinking among students in Greece elementary school. It was found that females score greater than males. Opposite to that research, Stoltzfus [22] examined gender issues, gender roles, and creativity among undergraduate students and shows that men have greater scores than women in verbal creativity, but not significantly. Also found out that males scored significantly greater than females on non-verbal creativity assignments. Although there have been several studies conducted on creativity and its relationship with gender, there are still too few studies that look at the role of gender differences in mathematical creativity specifically. So, in this paper, we will discuss whether gender influences students' mathematical creativity.

2. Method
The method used in this research is quantitative descriptive method. The purpose is to analyze gender differences in the mathematical creativity of students of SMP Batik Surakarta. The population in this study was eighth-grade students in SMP Batik Surakarta, the selection of samples to represent the school was done by stratified cluster random sampling technique and 56 students were selected. In collecting data, this study used an instrument in the form of a mathematical creativity test. The students were given 4 questions which were carried out in 60 minutes, each question presents 4 indicators of mathematical creativity such as fluency, flexibility, originality, and elaboration. The topic in the question is the circle. This research used one-way ANOVA. Before that, the prerequisite test is carried out such as normality and homogeneity test.
3. Result and Discussion
Based on the results of tests that have been given to students, the results are then tested for variance analysis with two prerequisite tests namely normality and homogeneity test. The normality test indicates the significance of $0.209 > 0.05$ and the homogeneity test indicates the significance of $0.543 > 0.05$. The hypothesis of the analysis of variance is below.

$H_0$: Males and females have the same test result of mathematical creativity  
$H_1$: Males and females have not the same test result of mathematical creativity

After calculation, it is obtained that the results of the significance are $0.141 > 0.05$, so $H_0$ is accepted and $H_1$ is rejected which is male and female students have the same result of mathematical creativity. This result is in line with research conducted by Ayıldız-Potur that there was no difference between males and females in using their abilities of creative thinking [16]. Similarly, a study conducted by Schermer [23] among undergraduate students revealed that there was no significant difference found between male and female students in creativity.

Mathematical creativity has 4 indicators, namely fluency, flexibility, originality, and elaboration. The male students obtained the highest score on the indicator of flexibility, while the female students obtained the highest score on the indicator of fluency. Also, when viewed from the average obtained by students, male students scored lower on average than female students, male students scored 37.86 while female students were 42.00. Besides, when viewed from the average obtained by students, male students scored lower on average than female students, male students scored 37.86 while female students were 42.00. Even so, the average value obtained by students is relatively low, so it can be said that mathematical creativity in SMP Batik Surakarta is still low. So the effort is needed to improve that ability. One way that can be done is by student-centered learning, so students become more active throughout learning. It was consistent with findings by Heong [24], "Students who were trained to think critically and creative often demonstrated a positive impact on the development of their education."

Below will be presented a diagram showing the achievements obtained by male and female students on each indicator of mathematical creativity that is shown in Figure 1.

![Figure 1. Student achievement on indicator of mathematical creativity](image-url)

Based on Figure 1, on the question that represents fluency indicators, 58% of male students can answer a given problem, meanwhile, 63% of female students could also answer that question. Even
though the given answers are not perfect, this shows that female students have a higher ability on the fluency indicator than male students. Also, more than fifty percent of the total male and female students can answer questions on this indicator of fluency so that it can be said that the scores obtained by male and female students on the indicator of fluency are quite high. On a question that represent indicators of flexibility, only 30% of male students were able to answer questions, almost the same as male students, only female students were able to answer only 33% of female students. This shows that on the question that represents a flexibility indicator, female students were better than male students. This is in line with the research conducted by Awamleh found out the presence of gender differences in creative thinking ability, their study shows that women had an advantage over men in flexibility [16]. Similarly, line with the research conducted by Kousoulas [20] found out that results of divergent thinking assignments show that female students got a higher score than male students in flexibility.

On the question that represents the originality indicator, 37% of male students could answer the question while 36% of female students could also answer that question. This indicator showed that even though men had a higher score than women, even though the difference was not significant. On the question that represents the elaboration indicator, 29% of male students were able to answer questions while 35% female students could answer. This shows that female students were excellent in solving problems in questions that represent an elaboration indicator than male students.

The results also show that the mathematical creativity of male and female students in completing questions following indicators of flexibility, originality, and elaboration is relatively low because less than fifty percent of male and female students were able to answer these questions. This happens because some students have difficulty understanding the problem and how to solve it. In Nguyen's opinion [25] which states that students have difficulty in concluding and most students are confused when the teacher asks them to describe what they know.

On the other hand, this may be caused by differences in the methods used by students in answering questions, each student has a different way of solving a problem. It is accordance with the statement of Zhang and Ching quoted by Anggraini [26] which states that students can apply the right method according to their individual preference, so they can develop their critical thinking.

Based on the explanation above, it is known that the mathematical creativity of female students is superior to male students in three indicators of mathematical creativity, which are fluency, flexibility, and elaboration, while for originality indicators male students are better than female students. Next, different answers from male and female students will be discussed on each indicator of mathematical creativity. The student answers will be shown below.

3.1. Fluency

Fluency is related to the diversity of student answers that can be produced. The following question will be presented with students' answers that fulfill the fluency in Figure 2.

Look at the picture on the side!

A circular wall clock with a center point O. The length of the wall clock radius is 14 cm, and the length of the bowstring AB = 30 cm. Determine the area of shaded area! Are there alternative answers? Explain if there is!

Figure 2. Question of fluency indicator.

The students' answers to the question in Figure 2 are presented in Figure 3.
central angle of cycle = area of sector
angle of cycle
90° = area of cycle
area of sector
360° = \frac{22}{7} \times 14 \times 14
90° = area of sector
360° \times 616 = area of sector
154 = area of sector

area of triangle = \frac{1}{2} \times base \times height
= \frac{1}{2} \times 14 \times 14
= 98 \text{ cm}

154 - 98 = 56 \text{ cm} (total shaded area)

---

In Figure 2(b), it appears that student understand the questions given, students know what steps can be done. Students first look for the area of cycle sector and find the area of the triangle, then find the area of the shaded area by reducing the area of cycle sector to the area of the triangle. The steps taken by students are correct, but students are not careful in writing units of the area of sector and triangle, so the answer becomes less precise. On the other hand, in Figure 2(c) appears that student understand the questions given, students know what steps can be done. The completion step that this student uses is different from the previous student in Figure 2(a), first, look for the area of \( \frac{1}{4} \) cycle and find the area of the triangle, then find the area of the shaded area by reducing area of \( \frac{1}{4} \) cycle to the area of the triangle. The steps taken and the answer by students are correct.
3.2. Flexibility

Flexibility is associated with the ability of students to generate different ideas, able to change the system or approach and be able to resolve the problem with the different directions of thinking from a problem. The following question will be presented with students' answers that fulfill the flexibility in Figure 4.

One day, class VIII student junior high school held a study tour in Bale Kambang Park in Surakarta. The teacher assign student to estimate the diameter of a tree that is large enough. Dina, Salwa, Berlva, Haris and Iman took the initiative to calculate the diameter of the tree by measuring the circumference of the tree. They link each other fingertips as shown in the picture on the side. The average length from the tip of the left finger to the right finger of each student is 120 cm. If exactly those five children touched their fingertip to surround the tree, can you estimate the length of diameter of the tree?

Figure 4. Question of flexibility indicator.

The students’ answers to the question in Figure 4 are presented in Figure 5.

In Figure 5(a), it appears that student understand the questions given, students know what steps can be done. Students determine the circumference of the tree first, then manipulate the formula of circumference. It is seen that students had no difficulty in solving the problems. On the other hand, Figure 5(c) shows that students understand the completion steps to be taken, but students were still difficult in the division operation.
3.3. Originality

Originality is the ability of students to try the approach in a way or method of an unusual or unique based on the ideas from the students themselves. The following question was presented with students’ answers that fulfill the originality in Figure 6.

![Question of originality indicator](image)

**Figure 6. Question of originality indicator.**

The students’ answers to the question in Figure 6 are presented in Figure 7.

**Figure 7. Sample of male student’s answer in Bahasa (a), its translation in English (b); Sample of female student’s answer in Bahasa (c), and its translation in English.**

In Figure 7(a), it appears that student only guess without a clear basis and the explanation of the answers presented by students is not supported by proof. On the other hand, Figure 7(c) shows that student does not have difficulty in solving problems, student understand what steps to do. The student takes the initiative to consider the length of the square so that it is easier to calculate the area of the shaded area.
3.4. Elaboration

Elaboration is the student's ability to redefine a problem or situation and itemize in detail the steps of a problem given. The following question will be presented with students' answers that fulfill the elaboration in Figure 8.

![Pay attention to the picture on the side!](image)

The picture on the side is a cross section of 3 circular cans with a radius of 10 cm. What is the minimum length of rope needed to tie the 3 cans? Are there alternative answers? Explain if there is!

**Figure 8.** Question of elaboration indicator.

The students' answers to the question in Figure 8 are presented in Figure 9.

\[
PP^2 = OP^2 - (R - r)^2 \\
= 20^2 - (10 - 10)^2 \\
= 400 \\
PP = \sqrt{400} \\
= 20 \\
20 \text{ cm} \times 3 = 60 \text{ cm}
\]

**Figure 9.** Sample of male student’s answer in Bahasa (a), its translation in English (b); Sample of female student’s answer in Bahasa (c), and its translation in English.

In Figure 9(a), it appears that student make mistakes in understanding the purpose of the question so the student answer is wrong, but at least students have thought about the solution that will be done. On the other hand, Figure 9(c) shows that student does not have difficulty in solving problems, student understand what steps to do and solve the problem well.
4. Conclusion
In this study, the mathematical creativity of students of SMP Batik Surakarta still low. There was no significant difference in mathematical creativity found amid female and male students. But, when viewed from the average score of male and female students on each indicator of mathematical creativity, females are superior to males in three indicators of mathematical creativity, that are fluency, flexibility, and elaboration, while for originality indicators male students are superior to female students. Female students and male students have very different ways of thinking from their answers, even if viewed from the average results of male and female students do not have many different values. So it can be concluded that gender does not really have an influence on students’ mathematical creativity.

Acknowledgment
We thank the Master Program of Mathematics Education Universitas Sebelas Maret and SMP Batik Surakarta for the support given to our research.

References
[1] Neumann C J 2007 Fostering creativity: A model for developing a culture of collective creativity in science EMBO Reports 8 202-6
[2] Cropley A J 1992 More ways than one: Fostering creativity (New Jersey: Ablex)
[3] Haylock D W 1987 A framework for assessing mathematical creativity in schoolchildren Educational Studies in Mathematics 18 59-74
[4] Oystein H P 2018 An investigation of the relationship between age, achievement, and creativity in mathematics The Journal of Creative Behavior 10.1002
[5] Sriraman B 2005 Are giftedness & creativity synonyms in mathematics? The Journal of Secondary Gifted Education 17 20-36
[6] Bishara S 2016 Creativity in unique problem-solving in mathematics and its influence on motivation for learning Cogent Education 3 1-14
[7] Catarino P, Nascimento M M, Morais E, Campos H, and Vasco P 2019 Breaking the habit: engineering students’ understanding of mathematical creativity European Journal of Engineering Education 44 449-60
[8] Nadjafikhah M, Yaftian N and Bakhshalizadeh S 2012 Mathematical creativity: Some definitions and characteristics Procedia-Social and Behavioral Sciences 31 285–91
[9] Sriraman B 2004 The Characteristics of Mathematical Creativity The Mathematics Educator 14 19–34
[10] Poincaré H 1948 Science and method (York: Dover)
[11] Saito N 1998 Construction of a process of creating creativity model and its application. The Bulletin of Japanese Curriculum Research and Development 21 19-27
[12] Munandar U 2002 Kreativitas dan keterbukatan srategi mewujudkan potensi kreatif dan bakat (Jakarta: Gramedia Pustaka Utama)
[13] Nakin J B N 2003 Creativity and divergent thinking in geometry education University of South Africa
[14] Huai-en Y 2004 To foster students’ creativity through classroom teaching Beijing Technology & Business University
[15] Rudowicz E, Lok D and Kitto J 1995 Use of the Torrance tests of creative thinking in an exploratory study of creativity in Hong Kong primary school children: A cross-cultural comparison International Journal of Psychology 30 417-30.
[16] Bart W M, Hokanson B, Sahin I and Abdelsamea M A 2015 An investigation of gender differences in creative thinking abilities among 8th and 11th grad students Thinking Skill and Creativity 17 17-24
[17] Stephens K R, Karnes F A and Whorton J 2001 Gender differences in creativity among American Indian third and fourth grade students Journal of American Indian Education 40 1-19
[18] De Moss K, Milich R and De Mers S 1993 Gender, creativity, depression, and attributional style in adolescents with high academic ability Journal of Abnormal Child Psychology 21 455–67

[19] Hong E, Peng Y, O’Neil H F and Wu J 2013 Domain-general and domain-specific creative-thinking tests: Effects of gender and item content on test performance The Journal of Creative Behavior 47 89-105

[20] Kousoulas F and Mega G 2009 Students’ divergent thinking and teachers’ ratings of creativity: Does gender play a role? The Journal of Creative Behavior 43 209–22

[21] Stephens K R, Karnes F A and Whorton J 2001 Gender differences in creativity among American Indian third and fourth grade students Journal of American Indian Education 40 1–19

[22] Stoltzfus G, Nibbelink B L, Vredenburg D and Thyrum E 2011 Gender, gender role, and creativity. Social Behavior and Personality 39 425–32

[23] Schermer J 2004 Measured intelligence, achievement, openness to experience, and creativity Personality and Individual Differences 36 913-29

[24] Heong Y M, Othman W B, Yunos J B, Kiong T T, Hassan R B and Mohamad M M 2011 The level of Marzano Higher Order Thinking Skills among technical educational students International Journal of Social Science and Humanity 5 281-5

[25] Nguyen T M T and Thi T L N 2017 Influence of explicit higher order thinking skills instruction on students’ learning of linguistics Thinking Skills and Creativity scient direct 113-127

[26] Anggraini N P, Budiyono and Pratiwi H 2019 Analysis of high order thinking skills students at junior high school in Surakarta Journal of Physics: Conf. Series 1211 012077