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Research articles

Between gender and academic achievement: Creative thinking in mathematics problem solving among junior high school students

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Abstrak Berpikir kreatif siswa dapat dipengaruhi oleh jenis kelamin dan prestasi akademik. Penelitian terdahulu mengenai tingkat berpikir kreatif siswa dalam memecahkan masalah kebanyakan berdasarkan jenis kelamin saja atau prestasi akademik saja. Penelitian ini bertujuan untuk mengetahui perbedaan tingkat berpikir kreatif siswa laki-laki dan perempuan dengan prestasi akademik tinggi, sedang, dan rendah dalam menyelesaikan soal terbuka. Penelitian kualitatif ini melibatkan 18 siswa SMP kelas 7 yang dipilih berdasarkan perbedaan jenis kelamin dan prestasi akademik. Siswa menjawab dua soal materi geometri dan menyuarakan apa yang mereka pikirkan selama menjawab soal tersebut. Wawancara berbasis tugas dilakukan untuk mengeksplorasi jawaban siswa. Hasil analisis data menunjukkan bahwa tingkat berpikir kreatif siswa dengan perbedaan jenis kelamin dan prestasi akademik ternyata tidak konsisten untuk soal yang berbeda. Namun, terdapat kecenderungan bahwa untuk soal yang memuat gambar, semakin tinggi tingkat prestasi akademik siswa laki-laki dan perempuan, semakin tinggi pula tingkat berpikir kreatifnya dan siswa laki-laki mengungguli siswa perempuan. Penelitian ini juga menemukan perbedaan tingkat berpikir kreatif siswa berdasarkan dimensi berpikir kreatif dan bentuk soal. Implikasi dari temuan ini adalah perbedaan jenis kelamin dan prestasi akademik tidak cukup untuk menentukan tingkat berpikir kreatif siswa.

Kata kunci *Berpikir kreatif, Jenis kelamin, Prestasi akademik, Pemecahan masalah*

Abstract Students' creative thinking could be influenced by gender and academic achievement. Many studies have been carried out regarding levels of students' creative thinking in solving problems based on gender and academic achievement, respectively. This study aims to understand differences in the levels of creative thinking of male and female students with high, medium, and low academic achievement in solving open-ended questions. This qualitative study involved 18 seventh-grade junior high school students selected based on gender differences and academic achievement. These students answered two open-ended problems on geometry and thought aloud about what they were thinking while answering the questions. Task-based interviews were conducted to explore students' answers. Data analysis shows that the level of students' creative thinking, considering gender and academic achievement, appears to be inconsistent for different open-ended questions. However, there is a tendency that for figural questions, the higher the level of academic achievement, the higher the level of creative thinking, and male students outperform female students. This study also found differences in the level of creative thinking between the students based on the dimensions of creative thinking and the kinds of problems. The finding implies that gender differences and academic achievement are not adequate to determine the level of students' creative thinking.

Keywords *Creative thinking, Gender, Academic achievement, Problem-solving*

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Introduction

The National Council of Teachers of Mathematics (NCTM) has established problem-solving as a standard in mathematics learning (NCTM, 2000). Creative thinking is critical in solving mathematical problems (Hadar & Tirosh, 2019) and is designated as a 21st-century competency (Volman et al., 2020). Dere (2019) asserts that creative thinking skills ought to be developed from early age. Thus, students need to be nurtured with the skills.

Creativity, creative thinking, and mathematical problem-solving are topics that have attracted researchers' attention to date. Several researchers focus on the interplay between creativity and students' mathematical problem-solving (e.g., Kandemir & Gur, 2007; Tyagi, 2016) and between students' creative thinking and mathematical problem-solving (Ketelhut et al., 2020; Švecová et al., 2014). These studies found that creativity and creative thinking positively relate to problem-solving abilities and vice versa. Other studies focus on instruments to measure creative thinking abilities (Bart et al., 2017; Kim, 2017). Several researchers focused on levels of students' creative thinking when solving mathematical problems (Siswono, 2011; Yayuk & As' ari, 2020) and indicated that the levels vary for different students.

Differences in the levels of creative thinking have prompted researchers to identify the causal factors. Several researchers see the differences in gender factors (Abraham et al., 2014; Betancourt et al., 2022; Nada & Sari, 2022), gender and education level (Matud et al., 2007), student demographics (Anwar et al., 2018) and student academic achievement (Sari, 2016; Siswono, 2011; Suripah & Sthephani, 2017). Based on academic achievement factors, Anwar et al. (2012a) inquired into the differences in the creative thinking of high and low-academic achieving students, while Suripah and Sthephani (2017) also involving moderate-achieving students. Anwar et al. (2012) conducted quantitative research and other researchers (Manaf et al., 2022; Safarieh, 2020) conducted a literature study to see the relationship between creative thinking abilities and academic achievement. Yang and Zhao (2021) and Akpur (2020) examined the influence of creative thinking on academic achievement. Based on gender factors, Betancourt et al. (2022) stated that there is no difference in creative thinking between women and men, but differences in the brain structure of men and women are believed to result in differences in thinking patterns (Ingalhalikar et al., 2014). Nakano et al. (2021) has revealed that women are more creative than men, but still requires deeper analysis regarding the differences in the dimensions of creative thinking. Siswono (2011) and Suripah and Sthephani (2017) have examined differences in creative thinking based on academic achievement but have not examined gender differences.

It appears that previous studies have produced different conclusions regarding the levels of creative thinking in terms of gender differences or academic achievement. The differences are interesting to be studied further, especially by involving gender differences and academic achievement factors simultaneously as Türkmen and Sertkahya (2015) argued, academic achievement alone is not enough to determine students' level of creative thinking. Anwar et al. (2012a) have conducted quantitative research on the influence of academic achievement and gender on the level of creative thinking, but only involving low and high academic achievement. Suripah and Retnawati (2019) investigated students' mathematical creative thinking abilities based on academic level and gender, but the analysis was carried out separately. Thus, research regarding students' creative thinking abilities based on gender and academic achievement with simultaneous

analysis still needs to be carried out. This could provide a more detailed description of creative thinking levels in terms of gender differences and academic achievement.

This research attempts to understand the levels of students' creative thinking based on gender and academic achievement simultaneously. It is based on an argument that creative thinking can be formed through problem-solving activities (Švecová et al., 2014) involving open-ended problems (Lin & Lien, 2013). The creative thinking that is established when students solve open-ended problems is influenced by many factors (Anwar et al., 2012a; Matud et al., 2007; Nada & Sari, 2022). Thus, analyzing differences in students' creative thinking based on more than one factor could provide a better picture of the construct. Existing research tends to study only one factor, for example, gender (Nakano et al., 2021) and academic achievement (Safarieh, 2020). Gender differences influence creative thinking (Torrance, 1961) as well as academic achievement (Anwar & Aness, 2012) and it is intriguing to inquire into the variables simultaneously. Furthermore, this research examines the different levels from three dimensions of creative thinking; flexibility, flexibility, and novelty (Silver, 1997).

Literature Review

Creative thinking

Creative thinking is a skill that students need to face life's challenges in the 21st century. Students who have creative thinking skills tend to have curious, adventurous, courageous, flexible, and imaginative personalities (Hu et al., 2016) which are needed in problem-solving. Creative thinking skills can enable students to solve problems with various methods and various solutions based on their own thinking activities (Awang & Ramly, 2008). Creative thinking activities involve a series of cognitive activities to produce new ideas and solutions (Chavula et al., 2022). Therefore, creative thinking can be seen through fluency, flexibility, and novelty (Silver, 1997). Fluency can be seen from the variety of ideas that emerge when students respond to an assignment (Kozlowski et al., 2019). Flexibility refers to students' changing responses to a task (Leikin & Lev, 2007). The novelty lies in the originality of students' ideas or novelty in responding to tasks (Chesimet et al., 2016).

Everyone has creativity and is able to think creatively, but their creative potential and level of creative thinking are different (Siswono, 2011). Differences in levels of creative thinking can be influenced by many factors, including experience, thinking patterns, gender (Jia et al., 2019; Nada & Sari, 2022), level of education (Matud et al., 2007), academic abilities (Anwar & Aness, 2012), adversity quotient (Hasanah & Abdussakir, 2024), student demographics (Anwar et al., 2018), family environment (Jankowska & Karwowski, 2019; Yildiz & Yildiz, 2021), and teaching and learning environment (Henriksen & Mishra, 2013; Mursid et al., 2021). The level of creative thinking can be categorized into very creative (level 4), creative (level 3), quite creative (level 2), less creative (level 1), and not creative (level 0) (Siswono, 2011) refers to Silver's (1997) three dimensions of creative thinking.

This study refers to the dimensions of fluency, flexibility, and novelty (Silver, 1997) as aspects of creative thinking. Based on these three dimensions, this study then refers to Siswono (2011) classifying students' creative thinking levels. The levels and categories of creative thinking used in

this study are level 0 (not creative), level 1 (less creative), level 2 (quite creative), level 3 (creative) and level 4 (very creative). Following Rahayuningsih et al. (2021), open-ended questions are considered adequate for measuring the level of creative thinking. This is because solving open-ended questions can encourage students' creative thinking (Lin & Lien, 2013).

Academic achievement

Academic achievement can be seen through cognitive, affective, or psychomotor aspects (Syafi'i et al., 2018). The cognitive aspect can be a measure of student academic achievement that can be measured through tests, the results of which are expressed in numbers, letters, or sentences. Academic achievement can be seen from the scores obtained by students from tests (Kuiken & Vedder, 2020) or other academic work (Wichmann et al., 2018). Referring to the literature (Syafi'i et al. 2018; Kuiken & Vedder, 2020), academic achievement in this study is measured from the cognitive aspect of students' learning outcomes in mathematics through academic ability tests. Students' academic abilities are then divided into high categories ($80 \leq$ test score ≤ 100), medium ($70 <$ test score < 80), and low (test score ≤ 70) (Jibeen & Khan, 2016).

The correlation between academic achievement and creative thinking ability has attracted the attention of many researchers. Some researchers posit that there is a correlation between academic achievement and creative thinking ability (Pastor & David, 2017; Zhang et al., 2020), but others have stated there is no correlation (Anwar et al., 2012b). The differences in the research results prompted this research to be conducted to see more clearly the relationship between academic achievement and students' level of creative thinking.

Gender differences

Gender differences are seen as differences in roles, functions, and responsibilities between men and women which are the result of social construction (Simanjuntak et al., 2019). This social construction can form inequality between men and women (Auguste, 2022) including in work (Shah & Lerche, 2021). Gender differentiation is supported by many factors (Zhang & Wang, 2022) and has implications for various aspects of life (Adisa et al., 2019) including in the field of education.

Gender differences are believed to influence the way women and men think and solve problems. Darmaji et al. (2022) found that gender differences affect critical thinking skills. Shen et al. (2015) show that women are more dominant in divergent thinking while men are more dominant in convergent thinking. Piaw (2014) and Zhang et al. (2020) stated that gender differences are a significant factor in creative thinking skills.

Several studies examining the differences in creative thinking abilities between men and women have found different results. Some show that men are more creative than women (Ayasrah et al., 2023; Matud et al., 2007; Nurmitasari & Astuti, 2017), women are more creative than men (Nakano et al., 2021; Ülger & Morsünbül, 2016), and others show no difference between men and women (Pastor & David, 2017). The difference in research results related to gender differences in creative thinking abilities is also the reason for conducting this study.

Gender, academic achievement, and creative thinking

Several studies have shown that many factors influence a person's ability to think creatively. These factors include, for example: experience, thinking patterns and gender (Jia et al., 2019; Nada & Sari, 2022), level of education (Matud et al., 2007), academic achievement (Anwar & Aness, 2012), student demographics (Anwar et al., 2018), family environment (Jankowska & Karwowski, 2019; Yildiz & Yildiz, 2021), and teaching and learning environment (Henriksen & Mishra, 2013; Mursid et al., 2021). Among the various factors, gender and academic achievement are two factors that have attracted much attention from researchers.

Prior studies (Abraham et al., 2014; Betancourt et al., 2022) have examined the levels of creative thinking based on gender, while other studies (Anwar et al., 2012b; Sari, 2016; Siswono 2011; Suripah & Sthephani, 2017) have focused on academic achievement, respectively. Studies on the level of creative thinking based on gender differences found that men outperform women, women outperform men, and no difference between men and women. If examined based on differences in academic achievement, some found that students with high academic achievement will have a higher level of creative thinking, but some found the opposite. The differences in the results of previous studies indicate the importance of examining the level of creative thinking based on gender and academic achievement simultaneously.

Methods

This research followed a qualitative approach to determine the level of students' creative thinking based on gender and academic achievement. This research used two open-ended problems on geometry, which aimed to measure the level of student's creative thinking in the figural and verbal aspects.

Participants

This research was carried out at a state Islamic junior high school in Blitar, East Java, Indonesia. This school is considered a favorite and A-accredited school. There are six state Islamic junior high schools in Blitar; the researchers chose one school by considering the input of students to the school. The school selected is the school whose student input has the best academic achievements compared to other schools. The researchers assume that students' creative thinking levels will be easily observed in this school. Initial observations showed that students in the selected schools were easy to communicate with, which is an important factor for data collection. Next, the researcher applied for a letter of permission to conduct research and maintain the confidentiality of the school's identity.

The data source for this research is seventh-grade students from an Islamic junior high school with different genders and academic achievements. These differences in gender and academic achievement are per the research objectives, namely mapping and analyzing levels of creative thinking based on differences in gender and academic achievement. Researchers determine the source of research data based on the results of academic ability tests and teacher recommendations. The academic ability test contained ten problems on junior high school mathematics material and was validated by two mathematics education lecturers and one mathematics teacher. The

mathematics teacher's recommendations were made to determine the suitability of the student's level of academic achievement based on records of student learning outcomes and the results of academic ability tests conducted by researchers. Of the 50 seventh-grade students who took the academic ability test, 18 students were selected as data sources, and they were willing to participate in this study, and the researcher maintained their confidentiality. Table 1 presents participants and their academic achievement.

Table 1. Research participants

Initial	Gender	Academic achievement	Student ID
AJUM	Male	High	MH1
MFZZ	Male	High	MH2
RA	Male	High	MH3
AFZ	Male	Medium	MM1
FAR	Male	Medium	MM2
ZAPJ	Male	Medium	MM3
MRA	Male	Low	ML1
ARR	Male	Low	ML2
FF	Male	Low	ML3
AU	Female	High	FH1
RAC	Female	High	FH2
AA	Female	High	FH3
DR	Female	Medium	FM1
L	Female	Medium	FM2
SAY	Female	Medium	FM3
RN	Female	Low	FL1
MDFA	Female	Low	FL2
VBM	Female	Low	FL3

Data collection

The data collection instrument for this research includes two open-ended problems, a think-aloud command, and a task-based interview guide. These three instruments have been validated by two mathematics education lecturers and a mathematics teacher before being used to collect data. After being revised according to the validator's suggestions, the open-ended problems used in the study were as shown in Figure 1. Item (a) places more emphasis on the figural aspect and Item (b) places more emphasis on the verbal aspect.

Rectangle ABCD has a length of 12 cm and a width of 5 cm.
(a) Draw at least three other shapes whose area is the same as the area of rectangle ABCD.
(b) Explain how to obtain other rectangles with an area twice the area of rectangle ABCD.

Figure 1. An open-ended problem given to students

Students who participated in this study answered the open-ended problem given and did think aloud, that is, voicing what they were thinking while answering the questions. The participants' thoughts aloud were recorded with a recording device. Furthermore, the researcher conducted task-

based interviews according to the student's answers to further explore or complete data. Task-based interviews were conducted by asking questions to ensure the emergence of creative thinking dimensions.

Data analysis

The data obtained was then analyzed qualitatively to determine the dimensions and level of students' creative thinking. The dimensions of students' creative thinking refer to Silver (1997) which contains the dimensions of fluency, flexibility, and novelty. The indicators used to analyze each dimension can be seen in Table 2 and Table 3.

Table 2. Indicators of creative thinking dimensions for Item (a)

Creative thinking dimensions	Indicators	Coding
Fluency	1. Students draw more than three shapes that have an area equal to the area of rectangle ABCD	A-Flu-1
	2. Students state the size and calculation of the area of another shape which has the same area as the area of rectangle ABCD	A-Flu-2
Flexibility	1. Students use different methods to get another shape whose area is the same as rectangle ABCD	A-Fle-1
	2. Students use different formulas to get another shape that has the same area as the area of rectangle ABCD	A-Fle-2
Novelty	1. Students draw unique shapes or combined shapes (consisting of several shapes)	A-Nov-1
	2. Students draw different shapes	A-Nov-2

Table 3. Indicators of creative thinking dimensions for Item (b)

Creative thinking dimensions	Indicators	Coding
Fluency	1. Students draw more than one rectangle that has an area twice the area of rectangle ABCD	B-Flu-1
	2. Students state the size and calculation of the area of another rectangle that has twice the area of rectangle ABCD	B-Flu-2
Flexibility	1. Students can explain how to get a rectangle that has twice the area of rectangle ABCD	B-Fle-1
	2. Students can explain different ways to get another rectangle that has twice the area of rectangle ABCD	B-Fle-2
Novelty	1. Students draw another rectangle with unusual side sizes (not just using whole numbers) according to the question prompt	A-Nov-1

The classification of students' creative thinking levels in solving open-ended questions in this research can be seen in Table 4. This classification of creative thinking levels refers to Siswono (2011) which contains the classifications of very creative, creative, quite creative, less creative and not creative.

Table 4. Classification of students' level of creative thinking

Levels and category	Dimensions		
	Fluency	*Flexibility*	*Novelty*
4 (very creative)	√	√	√
	-	√	√
3 (creative)	√	√	-
	√	-	√
2 (quite creative)	-	-	√
	-	√	-
1 (less creative)	√	-	-
0 (not creative)	-	-	-

Results

This research seeks to reveal differences in students' levels of creative thinking based on gender and academic achievement. The data collected for this purpose is in the form of students' answers to open-ended questions and is supported by data from think-aloud and task-based interviews. Based on these three data, analysis was carried out carefully to determine the dimensions of creative thinking that emerged in each research subject referring to Table 2 and Table 3. The following is an example of how analysis is carried out on data obtained from MH2 in solving Item (a).

After reading the question, MH2 started to answer Item (a) while doing think-aloud. The transcript of MH2's think-aloud results is presented in Figure 2.

> *Asked to draw another plane whose area is similar to rectangle ABCD. The area of the rectangle is 12×5 60* [writing...]. *This triangle* [drawing a triangle and determine its area]. *Triangle with height in this edge, a right triangle* [drawing the triangle and determine its area]. *Then* [pause...], *rectangle* [drawing the rectangle and determine its area]. *What else* [pause...] *rectangle ABCD. Square* [pause...]. *The square and rectangle* [drawing a triangle and determine its area]. *Then what else* [thinking...]. *It is just triangle and square* [pause...]. *The square is just this* [pause...]. *The triangle* [counting and writing...].

Figure 2. MH2's thinks-aloud transcript

After answering Item (a), MH2 produced 5 shapes, which contained 3 single shapes (isosceles triangle, right triangle, and rectangle) and 2 compound shapes (square and rectangle and triangle and square) as presented in Figure 3. Based on MH2's answers, the researcher then conducted a task-based interview, the transcript of which is presented in Figure 4.

Referring to MH2's answer for Item (a), think-aloud transcript, and task-based interview transcript, it appears that MH2 produced five images [A-Flu-1] and stated their area is the same as the area of rectangle ABCD well [A-Flu-2]. In addition, MH2 produced the fourth and fifth shapes in a different way, namely by combining shapes [A-Fle-1] so that the formula used to calculate their areas is also different [A-Fle-2]. The third and fourth shapes were produced by combining several shapes [A-Nov-1] so that the five shapes produced were all different [A-Nov-2]. Thus, MH2 met

the indicators of fluency, flexibility, and novelty, as mentioned in Table 2. Referring to Table 4, MH2 reached level 4 with the very creative category for Item (a).

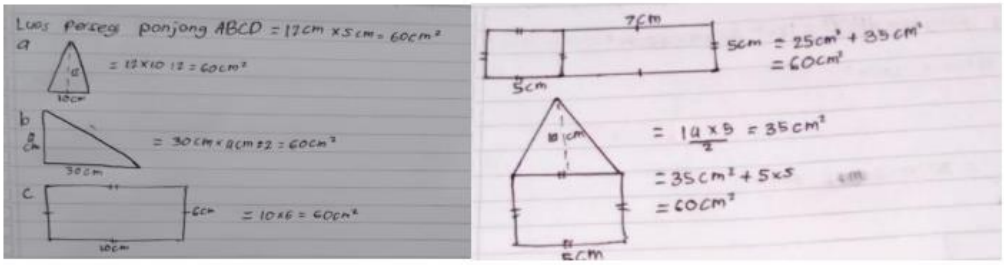

Figure 3. Five shapes drawn by MH2

R	*What did you draw?*
MH2	*I drew an isosceles triangle, a right triangle, a rectangle, a square joint with a rectangle, and a square joint with a triangle.*
R	*How did you find the area?*
MH2	*The triangle, its base 10 cm and height 12 cm, the area is 12 × 10 : 2. 120 : 2 = 60 cm^2. Another is a right triangle, the height 4 cm, base 30 cm, 4 × 30 : 2. 120 : 2 = 60 cm^2. The other is a rectangle, the lenght 6 cm, the area is 10 × 6 = 60 cm^2. This one is a joint square and rectangle. The square 5 cm, its area is 25. The lenght of the rectangle is 7 cm and its width is 5 cm, the area is 35. All is 60 cm^2. The last is two planes. First, it is a triangle with base 5 and height 14, its area is 5 × 14 : 2 = 35. Second, it is a square with 5, so it is 25. All is 35 + 25 = 60 cm^2.*

Figure 4. Interview transcript with MH2

Based on an in-depth analysis in a similar manner, the level of creative thinking for each level of academic achievement is presented in Table 5 for male students and in Table 6 for female students. Table 5 describes the dimensions and levels of creative thinking of male students based on academic achievement. Some interesting findings found in Table 5 can be explained as follows. For figural open-ended questions (item (a)), it was found that the higher the academic achievement, the higher the level of creative thinking of male students. Although this tendency also occurs in verbal questions, it turns out that some students with low academic achievement are more creative than students with medium academic achievement. This shows that the level of creative thinking of male students is not consistent when faced with different problems. Judging from the aspect of the dimensions of creative thinking, the higher the academic achievement of male students, the more novelty they appear, especially when solving figural open-ended questions (Item a).

Table 6 describes the dimensions and levels of creative thinking of female students based on academic achievement. Some interesting findings found in Table 6 can be explained as follows. For figural questions, it was found that the higher the academic achievement, the higher the level of creative thinking of female students. Although this tendency also occurs in verbal questions, it turns out that some students with moderate academic achievement are more creative than students with high academic achievement. This also shows that the level of creative thinking of female students is inconsistent when faced with different problems. Judging from the aspect of the dimensions of creative thinking, the higher the academic achievement of female students, the more the novelty dimension of their creative thinking emerges. Different things happen in the flexibility dimension,

female students with moderate academic achievements are more flexible than students with high academic achievements.

Table 5. Summary of dimensions and levels of creative thinking of male students

Academic achievement	Student ID	Item	Fluency	Flexibility	Novelty	Level	Category
High	MH1	(a)	-	-	√	2	Quite creative
		(b)	√	√	√	4	Very creative
	MH2	(a)	√	√	√	4	Very creative
		(b)	√	-	-	1	Less creative
	MH3	(a)	√	-	√	3	Creative
		(b)	√	√	-	3	Creative
Medium	MM1	(a)	-	-	-	0	Not creative
		(b)	√	-	-	1	Less creative
	MM2	(a)	-	-	-	0	Not creative
		(b)	√	-	-	1	Less creative
	MM3	(a)	√	-	-	1	Less creative
		(b)	√	-	-	1	Less creative
Low	ML1	(a)	-	-	-	0	Not creative
		(b)	-	-	-	0	Not creative
	ML2	(a)	-	-	-	0	Not creative
		(b)	√	√	-	3	Creative
	ML3	(a)	-	-	-	0	Not creative
		(b)	√	-	-	1	Less creative

Table 6. Summary of dimensions and levels of creative thinking of female students

Academic achievement	Student ID	Item	Fluency	Flexibility	Novelty	Level	Category
High	FH1	(a)	√	-	√	3	Creative
		(b)	√	-	√	3	Creative
	FH2	(a)	-	-	-	0	Not creative
		(b)	√	√	-	3	Creative
	FH3	(a)	-	-	√	2	Quite creative
		(b)	√	-	-	1	Less creative
Medium	FM1	(a)	√	-	-	1	Less creative
		(b)	√	√	-	3	Creative
	FM2	(a)	-	-	-	0	Not creative
		(b)	√	√	-	3	Creative
	FM3	(a)	-	-	-	0	Not creative
		(b)	√	√	√	4	Very creative
Low	FL1	(a)	-	-	-	0	Not creative
		(b)	-	-	-	0	Not creative
	FL2	(a)	-	-	-	0	Not creative
		(b)	-	-	-	0	Not creative
	FL3	(a)	-	-	-	0	Not creative
		(b)	-	-	-	0	Not creative

Furthermore, based on Table 5 and Table 6, it was found that for figural open-ended questions, it turns out that the level of creative thinking of male students tends to be higher than that of female students. On the other hand, for verbal open-ended questions, it turns out that the level of creative thinking of male students tends to be lower than that of female students. This means that male students are more creative in the drawing aspect and female students are superior in the verbal aspect. Another interesting finding is that on verbal open-ended, male students with low and high academic achievements turned out to have higher levels of creative thinking than female students with low and high academic achievements. On the contrary, male students with moderate academic achievement turned out to have lower levels of creative thinking than female students for verbal open-ended questions. This fact shows that the level of creative thinking of students of different genders and academic achievements is inconsistent for different questions. Judging from the dimensions of creative thinking, male students tend to be more fluent than female students, especially for high and low academic achievements. For the flexibility dimension, female students dominate male students on verbal questions, especially on moderate academic achievement. For the novelty dimension, male students dominate female students on figural questions, especially on high academic achievement, but on verbal questions, female students dominate male students, especially on medium academic achievement.

In summary, the findings of this present research are:

- the level of creative thinking of male and female students is different for different open-ended questions,
- male students tend to be more fluent than female students, but for aspects of flexibility and novelty, there are no differences,
- for specific open-ended questions, there is a tendency that the higher the student's academic achievement, the higher the level of creative thinking, but for other open-ended questions it turns out the opposite,
- the level of creative thinking of students with gender and academic achievement differences turns out to be inconsistent for different open-ended questions,
- the higher the academic achievement of male or female students, the more likely they are to emerge novelty dimensions in creative thinking, and
- in terms of the dimensions of creative thinking,
    - male students with high and low academic achievement dominate females on the fluency dimension for all types of open-ended questions,
    - female students with medium academic achievements dominate males on the flexibility dimension for verbal questions, and
    - male students with high academic achievements dominate females on the novelty dimension for figural questions, but for verbal questions, female students with moderate academic achievement dominate male students.

Discussion

This part discusses the main findings of the present study as follows.

First, the level of creative thinking of male and female students is different for different problems. This finding confirms previous research that compared the level of creative thinking of

men and women, the results vary according to the questions used. Distinct results, such as men having higher levels of creative thinking (Ayasrah et al., 2023; Nurmitasari & Astuti, 2017), women having higher levels of creative thinking (Nakano et al., 2021; Ülger & Morsünbül, 2016), and no differences in the creative thinking abilities of men and women (Pastor & David, 2017) are not contradictory. This can be caused by the type of questions and material used (He & Wong, 2011). Apart from that, differences in levels of creative thinking can also be influenced by thinking style (Piaw, 2014), psychological and intellectual characteristics (Budsankom et al., 2015), interests (Hong et al., 2013), experience (Jia et al., 2019; Nada & Sari, 2022), age (He et al. 2015), demographics (Anwar et al., 2018), family environment (Jankowska & Karwowski, 2019; Yildiz & Yildiz, 2021), and teaching and learning environment (Henriksen & Mishra, 2013; Mursid et al., 2021).

This research shows that male students are more creative for questions that emphasize the figural aspect, but female students are more creative for questions that emphasize the verbal aspect. This strengthens previous research results (for example Abraham et al., 2014; He & Wong, 2021; Kim, 2017; Shah & Gustafsson, 2021) that men are superior in the figural aspect while women are superior in the verbal aspect. Apart from that, it also indirectly strengthens research (Ulger, 2015) that visual and verbal aspects influence a person's creative thinking. Apart from other factors that influence a person's creative thinking, differences in the brain structure and way of thinking of men and women are also thought to be the cause of this difference. Women's brains are more reactive in verbal creative thinking while men's brains are more reactive in figural creative thinking (Razumnikova et al., 2009). When thinking creatively, men activate the part of the brain related to declarative memory, while women activate the part of the brain related to self-referential processing (Abraham et al., 2014).

Second, male students tend to be more fluent than female students, but for the dimensions of flexibility and novelty, there are no difference. This finding is in line with previous research results (Nurmitasari and Astuti, 2017) that male students show fluency dimensions but female students do not, but is contrary to research results that women are more fluent than men in mathematics (Ai, 1999) and there are no differences in male and female fluency (Bart et al., 2015). The finding that for the novelty dimension there is no difference between men and women supports the results of Hong et al., (2013) and Bart et al. (2015) research but contradicts the results of Ülger and Morsünbül (2016) research that women are higher than men for the novelty dimension. This finding also differs from research results (Hong et al., 2013; Shah & Gustafsson, 2021) that girls tend to outperform boys in terms of fluency and flexibility, especially in verbal tasks. This difference in findings is quite reasonable because the ability to think creatively is influenced by other factors, for example, the type of questions and material (He & Wong, 2011), intelligence (Pastor & David, 2017), thinking style (Piaw, 2014), experience (Hong et al., 2013; Jia et al., 2019), age (He et al. 2015), demographics (Anwar et al., 2018), family environment (Yildiz & Yildiz, 2021), and teaching and learning environment (Raeisoon et al., 2024). In addition, comparing the dimensions of creative thinking between men and women will vary greatly according to the differences of each student (Ülger & Morsünbül, 2016).

Third, there is a tendency that the higher a student's academic achievement, the higher their level of creative thinking. This means that academic achievement has a significant influence on

creative thinking abilities. This finding is in accordance with the results of previous research that academic achievement has a positive and significant correlation with creative thinking abilities (Ayasrah et al., 2023; Pastor & David, 2017; Zhang et al., 2020) but is different from the finding that academic ability has no effect on creative thinking abilities (Anwar et al., 2012b). In addition, in this study, it was found that for verbal questions, there were students with moderate academic achievement who had a higher level of creative thinking than students with high academic achievement. Likewise, there are students with low academic achievement who have a higher level of creative thinking than students with high academic achievement. This case supports Olatoye et al., (2010) research that Nigerian students with low academic achievement actually have high levels of creative thinking. This is supported by Gajda (2016) that the relationship between academic achievement and creative thinking is rather weak because there are still factors such as level of education, form of questions used, motivation, and intelligence. The relationship between academic achievement and creative thinking abilities will be stronger when students face verbal questions (Gajda et al., 2017).

Fourth, the level of creative thinking of students with different genders and academic achievements was inconsistent for different questions. This finding is in accordance with previous research (for example He & Wong, 2011; Hong et al., 2013) that different question items have an impact on students' level of creative thinking. Male and female students in all academic achievement categories show a tendency to be more creative when faced with verbal problems that require explanation than figural problems. The creative thinking dimension that is consistent for verbal questions is the fluency dimension, and this supports Russo's (2004) research. This also supports the opinion that to measure creative thinking abilities, more verbal questions are used (Kim, 2005). For verbal questions, female students tend to be more creative than males in the medium academic achievement category, while for low and high achievement, there is no significant difference. This is in line with the findings from Lau and Cheung (2010) and Kim (2017) that for verbal aspects, women outperform men for all dimensions of creative thinking (fluency, flexibility, and novelty).

Fifth, this research found that the higher the academic achievement of male or female students, the more likely they are to develop novelty dimensions in creative thinking. Novelty is the main characteristic of creative thinking, and a novel idea is based on the rarity and uniqueness of the idea (Mayseless et al., 2015), and this dimension is strongly influenced by academic ability (Zhang et al., 2020). In the research, for the high academic achievement category, male students were superior to female students in the novelty dimension. This supports previous research that men are smarter than women in coming up with new ideas (Proudfoot et al., 2015). The ability to generate new ideas was associated with alpha synchronization in frontal brain regions (Fink et al., 2009) and is mediated by the activity of several parts of the brain, including the medial prefrontal cortex (mPFC) and the posterior cingulate cortex (PCC) (Mayseless et al., 2015), and differences in the brain structure of men and women will have an influence on their creative thinking (Heilman, 2016). There are, of course, many other influencing factors, for example, thinking style (Piaw, 2014) and age (He et al., 2015).

The latest findings of this research are indirectly discussed in previous findings. Male students with high and low academic achievements dominate females in the fluency dimension for all types of questions according to research results (Nurmitasari & Astuti, 2017). Female students with

moderate academic achievement dominate males in the flexibility dimension for verbal questions in accordance with research results of Ai (1999) as well as the findings of Lau and Cheung (2010) and Kim (2017) regarding the verbal aspects of questions. Male students with high academic achievement dominate women on the novelty dimension for figural questions, but on verbal questions female students with moderate academic achievement dominate men. This finding is supported by Proudfoot et al. (2015) that men are smarter than women. Apart from that, men are superior in the figural aspect but women are superior in the verbal aspect (Abraham et al., 2014; He & Wong, 2021; Hong et al., 2013; Matud et al., 2007; Shah & Gustafsson, 2021).

The implication of the findings of this research is that research related to students' creative thinking abilities still needs to be carried out by paying attention to factors other than gender differences and academic achievement. The need for research on this topic based on other factors is also suggested by Nakano et al. (2021), for example, age, experience, thinking style, attitude, interests, motivation, psychology, intelligence, demographics, family environment, level of education, and learning methods at school. This research also shows that the form of the questions influences the level of creative thinking, but there is still little research that examines the influence of the question material on the level of creative thinking. So, examining the consistency of students' level of creative thinking when solving problems with different topics is intriguing. The implication of the findings of this research for mathematics learning practice is the importance of using open-ended questions, both verbal and figural, to stimulate and train students' creative thinking abilities.

It is possible that the findings of this research still contain bias and cannot be generalized, especially due to the limited number of subjects involved in this research. However, the limited number of subjects was anticipated by collecting data comprehensively through test methods, think loads, and task-based interviews. This means that the cases that emerged in this research show the real facts that may occur in students' creative thinking when solving open-ended questions, such as the case that students' level of creative thinking is inconsistent when faced with different problems even though their gender and academic achievement are the same. This limitation certainly encourages the need for further research, involving more research subjects.

Conclusion

There is inconsistency in the level of creative thinking when viewed from gender differences and academic achievement. Furthermore, the difference in the form of open-ended questions, namely figural and verbal questions, tends to have a major impact on this inconsistency. The inconsistency shows that differences in gender and academic achievement are not enough to determine the ability to think creatively. Differences in gender and academic achievement influence the level of creative thinking, but there are still other factors that also influence, for example, age, experience, thinking style, attitude, interests, motivation, psychology, intelligence, demographics, family environment, level of education, and learning methods in school. The factors of gender differences and academic achievement, together with other factors, influence the dimensions of creative thinking (fluency, flexibility, and novelty) that students emerge when solving open-ended questions. As a result, the dimensions of students' creative thinking are inconsistent on different questions, even though their gender and academic achievement are the same. One aspect that tends

to be consistent in the findings of this research is that open-ended verbal questions activate students' creative thinking abilities more than figural questions.

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