

EXPLORING THE RELATIONSHIP BETWEEN PREREQUISITE CONCEPTUAL UNDERSTANDING AND MATHEMATICAL CREATIVE THINKING IN STRAIGHT-LINE EQUATIONS

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Received 08 June 2026; Received in revised form 17 June 2026; Accepted 26 June 2026

ABSTRACT

This study was motivated by the still-low ability of students to understand prerequisite concepts and explore various problem-solving strategies in the topic of straight-line equations. The study aims to examine the relationship between the ability to understand prerequisite concepts and the mathematical creative thinking skills of junior high school students in the topic of straight-line equations. The study employed a quantitative approach with a correlational design involving 34 eighth-grade students at a private junior high school in Cirebon Regency. The sample was selected using purposive sampling. Data were collected through tests assessing conceptual understanding and mathematical creative thinking skills. Data analysis was conducted using the Spearman's rank correlation test and K-Means Clustering. The analysis results indicate a significant positive correlation of moderate strength between conceptual understanding and mathematical creative thinking, with a correlation coefficient of 0.499. Analysis of student responses revealed that the characteristics of mathematical creative thinking do not differ significantly across different levels of conceptual understanding. These findings indicate that high conceptual understanding does not fully guarantee the optimal development of all indicators of mathematical creative thinking. The research results imply that mathematics instruction should not only emphasize conceptual mastery but also provide students with opportunities to explore various problem-solving strategies and develop new ideas in problem-solving.

Keywords: conceptual understanding; mathematical creative thinking; k-means clustering

ABSTRAK

Kemampuan siswa dalam memahami konsep prasyarat dan mengeksplorasi berbagai strategi penyelesaian pada materi persamaan garis lurus perlu ditingkatkan. Penelitian ini bertujuan untuk menganalisis hubungan antara kemampuan pemahaman konsep prasyarat dan kemampuan berpikir kreatif matematis siswa SMP. Penelitian menggunakan pendekatan kuantitatif dengan jenis korelasional terhadap 34 siswa kelas VIII di SMP NU Lemahabang. Data diperoleh melalui tes uraian kemampuan pemahaman konsep dan kemampuan berpikir kreatif matematis. Analisis hubungan antarvariabel dilakukan menggunakan uji Rank Spearman, lalu metode K-Means Clustering digunakan untuk mengelompokkan siswa berdasarkan tingkat kemampuan pemahaman konsep sehingga hubungan pada setiap kelompok dapat dianalisis. Hasil penelitian menunjukkan terdapat hubungan positif yang signifikan dengan kekuatan sedang antara kemampuan pemahaman konsep dan kemampuan berpikir kreatif matematis pada seluruh sampel. Setelah dilakukan pengelompokan menggunakan K-Means Clustering berdasarkan tingkat kemampuan pemahaman konsep, hubungan pada setiap kluster tidak menunjukkan signifikansi statistik. Analisis jawaban siswa menunjukkan bahwa karakteristik kemampuan berpikir kreatif matematis pada setiap kluster tidak sepenuhnya berbeda. Temuan ini mengindikasikan bahwa kemampuan pemahaman konsep yang tinggi belum sepenuhnya menjamin berkembangnya kemampuan berpikir kreatif matematis secara optimal. Oleh

karena itu, pembelajaran matematika perlu memberikan kesempatan kepada siswa untuk mengeksplorasi berbagai strategi penyelesaian masalah.

Kata kunci: kemampuan berpikir kreatif matematis; kemampuan pemahaman konsep; k-means clustering



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Introduction

Developments in the 21st century require students to master various higher-order thinking skills necessary for life (Mahmudah et al., 2024). According to the Partnership for 21st Century Skills (2009), students are expected to develop twenty-first-century skills, commonly referred to as the 4C, which consist of critical thinking, creativity, communication, and collaboration. Among these competencies, creativity plays a crucial role, enabling students to generate diverse ideas and solutions to address various problems (Ezra & Levenson, 2025). In this context, mathematics is one of the disciplines that can foster creativity through problem-solving activities and the exploration of multiple solution strategies (Nahdi, 2019).

In mathematics, creativity is demonstrated through students' ability to generate a variety of ideas and meaningful alternative approaches to solving a problem. Guilford (1950) identified four key indicators of creative thinking: fluency, flexibility, originality, and elaboration. Developing these aspects of creativity requires more than procedural proficiency. Students need a meaningful understanding of mathematical concepts that enables them to connect ideas, adapt strategies, and construct solutions independently rather than merely reproducing previously learned procedures (Jonsson et al., 2020).

Conceptual understanding is widely recognized as a fundamental component of mathematical proficiency. It refers to students' ability to comprehend mathematical ideas, recognize relationships among concepts, and explain those concepts in their own words (Giriansyah et al., 2023). According to Kilpatrick et al. (2001), conceptual understanding is reflected in students' ability to restate learned concepts, distinguish examples from non-examples, and classify objects according to their defining characteristics. Strong conceptual understanding is essential for building a well-organized knowledge structure, which in turn supports more flexible and creative thinking (Meier et al., 2023).

One of the mathematical topics that requires the exploration of various solution strategies is straight-line equations (Puspitasari & Siswono, 2024). This topic involves the use of symbols, graphical representations, and relationships among concepts, requiring students to determine the slope and equation of a line based on the information provided (Irwanto et al., 2023). To understand straight-line equations, students must possess a solid understanding of prerequisite concepts, including basic arithmetic, the Cartesian coordinate system, and algebra, which should be acquired prior to studying this topic (SN et al., 2020). However, Yolanda & Rahmi (2025) reported that students still make many errors in solving straight-line equation problems due to inadequate understanding of the underlying concepts and principles.

Findings from a preliminary study conducted at SMP NU Lemahabang revealed that more than 51-58% of the students still relied heavily on solution examples provided by their teachers and were not accustomed to exploring alternative solution strategies. Interviews with mathematics teachers also indicated that students frequently struggled when faced with problems that differed from previously demonstrated examples. These findings suggest that many students experience challenges not only in understanding mathematical concepts but also in developing flexible approaches to problem solving. Similar concerns have been reported by Bohalima (2022), who found that students' conceptual understanding remained relatively low, particularly in foundational topics such as straight-line equations. Likewise, Ramadhani et al. (2025) reported that many junior high school students rarely explored alternative solution methods when solving mathematical problems. Such conditions highlight the importance of investigating how conceptual understanding is associated with students' mathematical creative thinking.

Several studies indicate a correlation between conceptual understanding and mathematical creative thinking. Komarudin et al. (2023) found a significant relationship between conceptual understanding and creative thinking ability. Similar results were also found by Trianggono (2017), indicating a correlation between conceptual understanding and mathematical creative thinking skills are interrelated. However, these studies have focused only on the general relationship between conceptual understanding and mathematical creative thinking skills.

To obtain a more detailed picture of the relationship, students need to be grouped based on their level of conceptual understanding. One method that can be used is K-Means clustering, which groups data based on the similarity of specific characteristics. This method is considered effective in categorizing student abilities so that the resulting groups better reflect the actual characteristics of the data (Putri & Yudhanegara, 2025). Such grouping is necessary because students with the same achievement levels may have different ability profiles (Gilmore et al., 2017). Thus, the relationship between prerequisite conceptual understanding skills and mathematical creative thinking skills can be analyzed in greater detail within each student group.

Previous studies generally only analyzed the relationship between conceptual understanding and mathematical creative thinking skills as whole, whereas this study analyzes that relationship at each level of conceptual understanding obtained through grouping using K-means clustering. Additionally, this study describes the characteristic of mathematical creative thinking skills within each student group. Therefore, this study aims to analyze the relationship between prerequisite conceptual understanding skills and mathematical creative thinking skills among junior high school students on straight-line equation material, analyzed the relationship between these two abilities at each level of conceptual understanding, and describe the characteristics of mathematical creative thinking skills based on indicators of fluency, flexibility, elaboration, and originality.

Research Methods

This study employed a quantitative correlational design to examine the relationship between students' understanding of prerequisite concepts and their mathematical creative thinking skills. A correlational design is appropriate for

investigating the degree and direction of the relationship between two or more variables without manipulating them (Hasbi et al., 2023). The population consisted of all eighth-grade students at SMP NU Lemahabang, totaling 242 students across seven classes. The sample was selected using purposive sampling, which involves selecting participants based on specific criteria relevant to the research objectives (Tajik et al., 2024). The selected class was recommended by the mathematics teacher and was considered capable of participating in the entire research process. Consequently, one class consisting of 34 students was chosen as the research sample.

Data were collected through two written open-ended tests, a prerequisite conceptual understanding test and a mathematical creative thinking test. The conceptual understanding test assessed students' mastery of prerequisite concepts for linear equations based on the indicators proposed by Kilpatrick et al (2001), including the ability to restate learned concepts, identify examples and non-examples of a concept, and classify objects according to the defining characteristics of a concept. The mathematical creative thinking test focused on the topic of linear equations and was developed based on Guilford (1950) indicators of creativity, namely fluency, flexibility, elaboration, and originality.

Prior to data collection, both instruments underwent validity and reliability testing. The conceptual understanding test initially consisted of seven items, of which one item was found to be invalid and subsequently excluded, leaving six valid items for use in the study. The mathematical creative thinking test consisted of four items, all of which met the validity criteria. Reliability analysis showed that the conceptual understanding test yielded a Cronbach's alpha coefficient of 0.791, while the mathematical creative thinking test produced a coefficient of 0.738. These results indicate that both instruments possessed acceptable internal consistency and were suitable for research purposes. A summary of the validity and reliability results is presented in Table 1.

Table 1. Validity and Reliability Test Results of the Test Instruments

Instrument	Number of Items	Validity Results	Reliability
Conceptual Understanding Test	7	6 valid items, 1 invalid item	$\alpha = 0.791$ (Reliable)
Mathematical Creative Thinking Test	4	All items valid	$\alpha = 0.738$ (Reliable)

Each test item was scored using an analytic rubric aligned with the indicators being assessed. Responses were evaluated on a scale ranging from 0 to 4 based on their accuracy, completeness, and relevance to the assessed indicator. A score of 0 was assigned when a response was missing or did not reflect the intended indicator, whereas a score of 4 was awarded for a complete and accurate response. The conceptual understanding test consisted of six valid items with a maximum score of 32. The difference between the number of items and the maximum score resulted from several items assessing more than one indicator and therefore receiving separate scores. The mathematical creative thinking test consisted of four items with a maximum score of 16.

Data were analyzed using IBM SPSS Statistics 25. The analysis was conducted in several stages. First, the validity and reliability of the instruments were evaluated. After the instruments met the required criteria, they were administered to the research sample. Second, a normality test was conducted using the Shapiro–Wilk test because the sample size was fewer than 50 participants. The selection of the correlation test was based on the results of the normality test. Pearson’s correlation was used for normally distributed data, whereas Spearman’s rank correlation was applied when the normality assumption was violated (Lestari & Yudhanegara, 2015).

After the correlation analysis for the entire sample was completed, the test data on conceptual understanding skills were grouped into three clusters using the K-Means clustering method. K-Means clustering groups data based on similarity of the characteristics by minimizing variation within each cluster (MacQueen, 1967). The determination of three clusters ($k=3$) was based on the research objective to group students into high, moderate, and low levels of conceptual understanding skills. Grouping into these three ability categories has been used in previous studies at applied K-Means clustering to student skills data (Putri & Yudhanegara, 2025). Clustering was performed using Euclidean Distance with randomly selected initial centroids and iterative centroid updates until convergence was achieved. Because clustering was conducted on a single variable, namely conceptual understanding scores, data standardization was not required.

Subsequently, a correlation analysis was performed on each cluster using the same correlation test to obtain an overview of the relationship between conceptual understanding skills and mathematical creative thinking skills at each level of conceptual understanding skills. The criteria for hypothesis testing for correlation are as follows:

If the significance value (p -value) $< 0,05$, then H_0 is rejected.

If the significance value (p -value) $\geq 0,05$, then H_0 is not rejected.

Where,

H_0 : There is no significant relationship between students' conceptual understanding and mathematical creative thinking skills,

H_1 : There is a significant relationship between students' conceptual understanding and mathematical creative thinking skills.

The correlation coefficient values were then interpreted. The interpretation is based on Guilford’s Empirical Rules in Lestari & Yudhanegara (2015) and is shown in Table 2.

Table 2. Interpretation of Correlation Coefficients

Correlation Coefficient (r)	Interpretation
$0.00 < r < 0.20$	Very weak relationship (negligible)
$0.20 \leq r < 0.40$	Weak relationship
$0.40 \leq r < 0.70$	Moderate relationship
$0.70 \leq r < 0.90$	Strong relationship
$0.90 \leq r \leq 1.00$	Very strong relationship

Based on Table 2, in addition to indicating the strength of the relationship, the correlation coefficient also indicates the direction of the relationship between two

variables. A positive correlation coefficient indicates a positive relationship, while a negative correlation coefficient indicates an inverse relationship. A correlation coefficient value close to zero indicates that the relationship between the two variables is weaker. After the correlation analysis was completed, a descriptive analysis was conducted on the responses of students with the highest scores in mathematical creative thinking skills within each cluster. The analysis was performed to describe the characteristics of mathematical creative thinking skills based on the indicators of fluency, flexibility, elaboration, and originality at each level of conceptual understanding.

Overall, the analysis procedures included administering the tests, testing the prerequisite assumptions, conducting a correlation analysis for the entire sample, grouping students using K-Means clustering based on their conceptual understanding scores, performing correlation analyses within each cluster, and interpreting the results of these analyses. The research flowchart is presented in Figure 1.

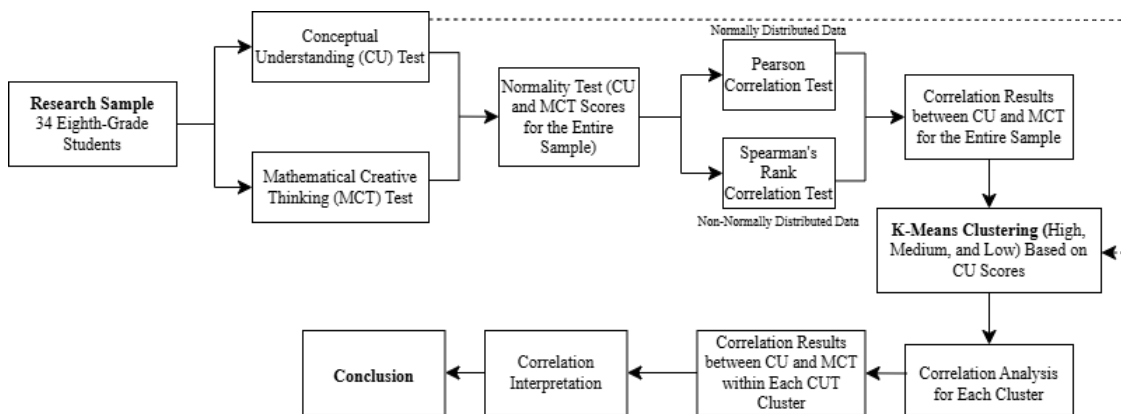


Figure 1. Flowchart of the Data Analysis Procedure

Results and Discussion

The study was conducted at SMP NU Lemahabang, with a sample size of 34 students. Data were obtained from the results of the conceptual understanding and mathematical creative thinking tests. Descriptive statistics for both variables are presented in Table 3.

Table 3. Descriptive statistics of conceptual understanding and mathematical creative thinking tests

Test	Data			
	Minimum	Maximum	Mean	Standard Deviation
Conceptual Understanding	9.38	50.00	25.55	11.83
Mathematical Creative Thinking	43.75	87.50	64.59	12.46

Based on Table 3, the mean scores of conceptual understanding and mathematical creative thinking indicate different levels of achievement. However, both variables exhibit a fairly diverse data distribution based on relatively large

standard deviations. This indicates that student’s ability characteristics are not homogeneous. Thus, the relationship between conceptual understanding and mathematical creative thinking skills may differ among students as well as across different levels of conceptual understanding. Before testing the research hypotheses, a normality test was conducted using the Shapiro–Wilk test. The results are presented in Table 4.

Table 4. Results of the shapiro–wilk normality test

Data	n	df	Sig.	Decision
Conceptual Understanding	34	33	0.035	H ₀ rejected
Mathematical Creative Thinking	34	33	0.037	H ₀ rejected

As shown in Table 4, the results of the normality test on the data regarding conceptual understanding and creative thinking indicate that data are not normally distributed. Since the assumption of normally is not met, the hypothesis testing proceeds with the Spearman’s rank correlation test to examine the relationship between student’s conceptual understanding and mathematical creative thinking, as well as to examine the relationship between the two abilities in terms of the level of conceptual understanding. Table 5 below shows the results of the correlation test on the overall data for conceptual understanding and creative thinking.

Table 5. Spearman’s rank correlation results for the entire sample

n	r_s	Sig	Decision	Correlation Direction	Relationship Strength
34	0,50	0,003	H ₀ Rejected	Positive	Moderate

Based on Table 5, the results of the Spearman’s rank correlation test on the entire sample indicate a significant relationship between conceptual understanding and mathematical creative thinking. The correlation coefficient, which falls into the moderate category with a positive direction, suggests that students with better conceptual understanding tend to have better mathematical creative thinking skills as well. This finding indicates that conceptual understanding plays a role in supporting students to generate various ideas, strategies, and solutions in solving mathematical problems. However, because the strength of the relationship obtained is in the moderate category, mathematical creative thinking is not only related to conceptual understanding but is also influenced by other factors not analyzed in this study.

Next, conceptual understanding was divided into three groups using K-Means clustering. The three groups were high, medium, and low clusters, in order to examine the relationship between conceptual understanding and creative thinking ability based on students’ levels of conceptual understanding. The results of the clustering of conceptual understanding using K-Means are presented in Table 6.

Table 6. Initial centroids of k-means clustering for conceptual understanding

	Cluster 1	Cluster 2	Cluster 3
Conceptual Understanding	9	28	50

In Table 6, initial centroids were randomly selected from the conceptual understanding variable and then used in the initial clustering before the iteration process began. The calculation process began by calculating the distance of each data point from each centroid, after which each point was assigned to the nearest centroid. The centroids were then updated by calculating the average of all points in that cluster. This step is repeated until the number of members in each cluster remains unchanged. Based on the calculations, convergence occurs in the third iteration. Table 7 presents the final K-Means clustering centroids for conceptual understanding.

Table 7. Final Centroids of k-means clustering for conceptual understanding

	Cluster 1	Cluster 2	Cluster 3
Conceptual Understanding	15	28	43

The final centroids shown in Table 7 indicate that convergence was achieved after three iterations. The resulting cluster memberships are presented in Table 8.

Table 8. Results of grouping conceptual understanding

Cluster	Number of Students	Category
Cluster 1	15	Low
Cluster 2	11	Medium
Cluster 3	8	High

Based on Table 8, students were successfully grouped into three clusters based on their level of conceptual understanding using the K-Means clustering method: high, medium, and low. This grouping allowed for an analysis of the relationship between conceptual understanding and mathematical creative thinking at each level of conceptual understanding. Next, a Spearman's rank correlation test was conducted for each cluster. The results of the correlation test for cluster 1 are presented in Table 9.

Table 9. Spearman's rank correlation results for cluster 1

n	r_s	Sig	Decision	Correlation Direction	Relationship Strength
15	0,162	0,564	H ₀ Not Rejected	Positive	Very Weak

Based on Table 9, there is no significant relationship between conceptual understanding and mathematical creative thinking in Cluster 1. A positive correlation coefficient with a very weak relationship indicates that students with better conceptual understanding in this cluster do not necessarily have better mathematical creative thinking. These results indicate that variations in mathematical creative thinking among students in Cluster 1 are likely more related

to factors other than conceptual understanding. Furthermore, the results of the correlation test for Cluster 2 are presented in Table 10.

Table 10. Spearman's rank correlation results for cluster 2

n	r_s	Sig	Decision	Correlation Direction	Relationship Strength
11	0,461	0,153	H_0 Not Rejected	Positive	Moderate

Based on Table 10, there is no significant relationship between conceptual understanding and mathematical creative thinking in Cluster 2. Although the correlation coefficient indicates a positive relationship of moderate strength, the results suggest that students with better conceptual understanding tend to have better mathematical creative thinking; however, this trend is not consistent enough to indicate a statistically significant relationship. Thus, conceptual understanding has not shown a significant association with mathematical creative thinking in students in Cluster 2. Furthermore, the results of the correlation test for Cluster 3 are presented in Table 11

Table 11. Spearman's rank correlation results for cluster 3

n	r_s	Sig	Decision	Correlation Direction	Relationship Strength
8	0,114	0,788	H_0 Not Rejected	Positive	Very Weak

Based on Table 11, there is no significant relationship between conceptual understanding and mathematical creative thinking in Cluster 3. A positive correlation coefficient with a very weak relationship indicates that students with better conceptual understanding in this cluster do not necessarily have better mathematical creative thinking. These results indicate that conceptual understanding has not shown a consistent relationship with mathematical creative thinking among students in Cluster 3. A scatter plot illustrating the relationship between conceptual understanding and mathematical creative thinking across each cluster is presented in Figure 2.

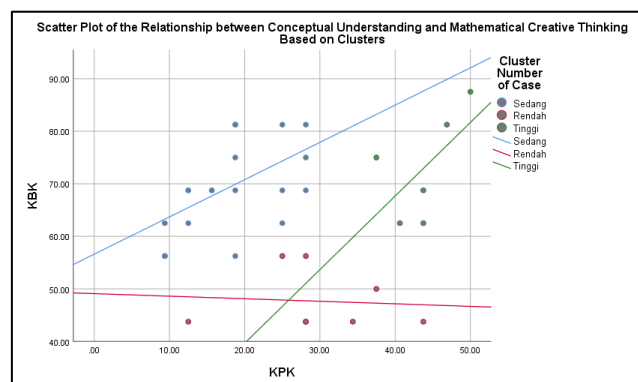


Figure 2. Scatter plot of the relationship between conceptual understanding and mathematical creative thinking across clusters

Based on Figure 2, the pattern of the relationship between conceptual understanding and mathematical creative thinking differs across each cluster. The

moderate cluster shows a clearer tendency toward a positive relationship, whereas the low and high clusters exhibit a more varied data distribution, meaning that an increase in conceptual understanding is not always followed by an increase in mathematical creative thinking. These findings indicate that students with relatively similar levels of conceptual understanding may still possess different levels of mathematical creative thinking. These results align with the correlation test, which indicates a moderate-category relationship in the moderate cluster and a very weak-category relationship in the low and high clusters. Thus, the relationship between conceptual understanding and mathematical creative thinking is not uniform across all levels of students' conceptual understanding.

Based on the data analysis results, it was found that students' conceptual understanding and mathematical creative thinking have a significant relationship in the moderate category across the entire sample. This is indicated by a Spearman correlation coefficient of 0.499 with a significance level of 0.003. This finding aligns with the research by Trianggono (2017) and Akhsani et al. (2025), which showed that mathematical creative thinking is related to good conceptual mastery. This positive relationship can also be explained through Skemp's relational understanding theory, which states that students who understand concepts meaningfully will find it easier to connect their existing knowledge to new situations and apply concepts more flexibly (Skemp, 1978). Strong conceptual understanding enables students to develop various problem-solving strategies based on their own reasoning, which is a component of mathematical creative thinking (Jonsson et al., 2020).

However, after conceptual understanding was grouped using K-Means Clustering, no significant relationship was found within each cluster. This result may be due to the narrowing variation in conceptual understanding within each group or the presence of other factors beyond conceptual understanding (Gayatri & Yudhanegara, 2025). This finding aligns with Gilmore et al. (2017) and Padilla & Orongan (2025), who demonstrated that students with relatively similar ability levels can exhibit different profiles of creative thinking ability. In addition to conceptual understanding, mathematical creative thinking is also related to learning experiences, the learning environment, and students' psychological conditions (Niu et al., 2022; Rawlings & Cutting, 2024). These findings indicate that the development of mathematical creative thinking is supported not only by conceptual mastery but also by learning experiences that encourage the exploration of various problem-solving strategies.

Differences in the strength of the relationship between conceptual understanding and mathematical creative thinking across each cluster are also reflected in the characteristics of students' responses on each indicator of mathematical creative thinking. An analysis was conducted on students with the highest scores in mathematical creative thinking within each cluster to describe the characteristics of mathematical creative thinking at each level of conceptual understanding. The results for the Fluency indicator are presented in Figure 3 below.

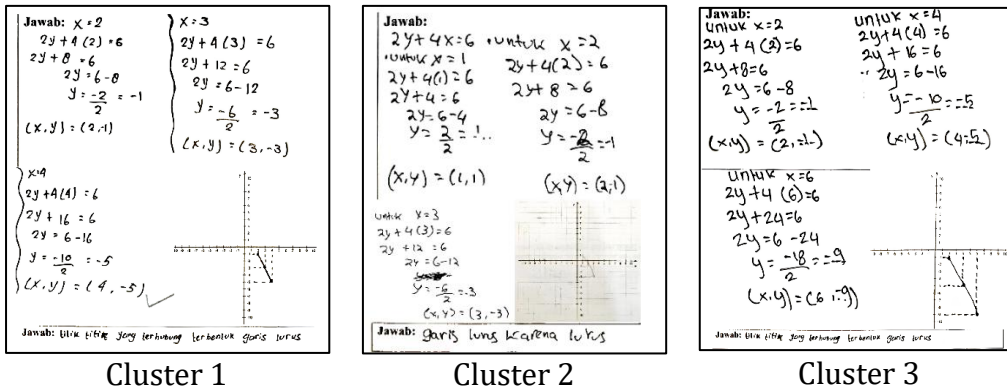


Figure 3. Students' responses to the fluency indicator across clusters

Based on Figure 3, no significant differences were observed in the Fluency indicator. All three students were able to correctly identify more than three pairs of points that satisfied the equation. This finding suggests that generating multiple correct answers is relatively easier to achieve because students can still rely on procedures they have previously learned. Furthermore, students' responses on the flexibility indicator are presented in Figure 4.

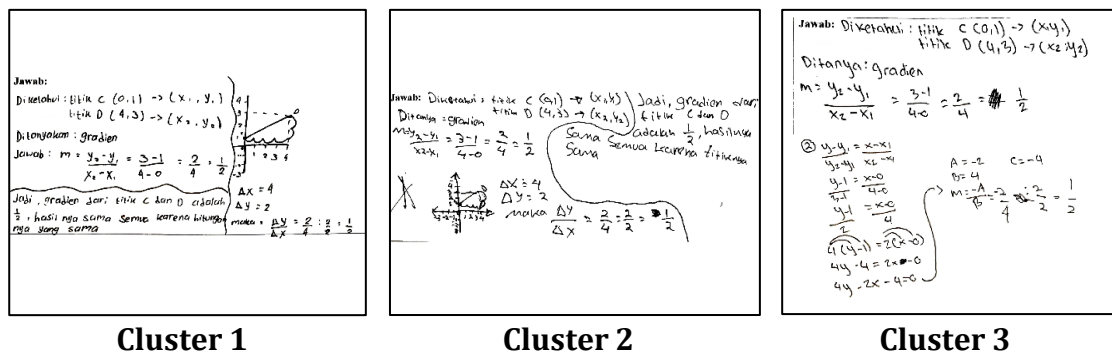


Figure 4. Students' responses to the flexibility indicator across clusters.

Based on Figure 4, all three students were able to use more than one strategy to determine the gradient, even though the representations used differed. These results indicate that students in each cluster have demonstrated flexibility in employing various problem-solving approaches. Next, students' responses to the elaboration indicator are presented in Figure 5.

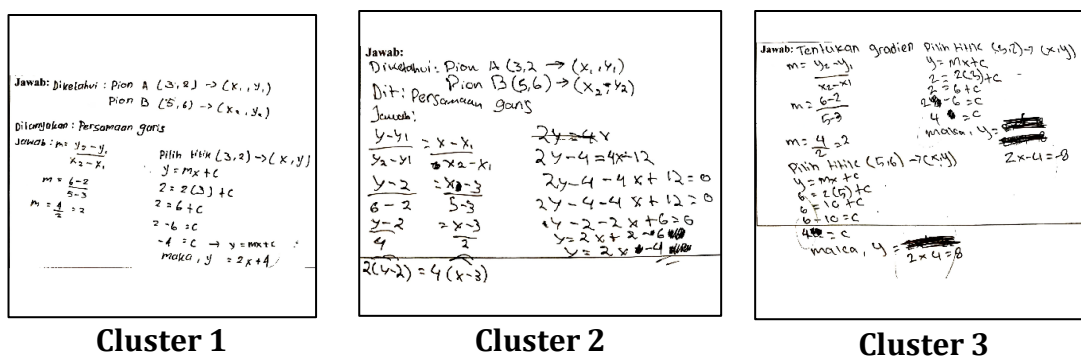


Figure 5. Students' responses to the elaboration indicator across clusters

Based on Figure 5, differences between clusters begin to emerge regarding the elaboration indicator. All three students were able to detail their solution steps, but the level of precision and completeness of their answers varied. Students in the middle cluster demonstrated more complete and accurate solutions compared to those in the low and high clusters. This finding suggests that conceptual understanding is more evident in the precision and completeness of solution steps than in the ability to generate numerous ideas. Finally, Figure 6 presents the students' answers to the question with the originality indicator.

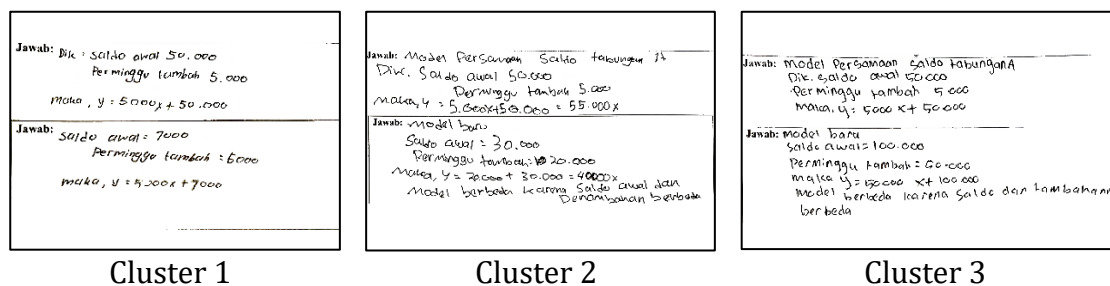


Figure 6. Students' responses to the originality indicator across clusters

Based on Figure 6, regarding the originality indicator, none of the students in any cluster were able to provide accurate answers. Originality requires students to generate ideas that are unconventional and differ from standard procedures. In this study, students across all clusters still tended to modify familiar strategies rather than develop new models. These findings suggest that conceptual mastery alone is not sufficient to generate novel ideas. The ability to be original requires learning experiences that provide students with opportunities to explore various possible solutions and develop non-routine strategies.

Based on the analysis of students' responses, the characteristics of mathematical creative thinking abilities at each level of conceptual understanding are not entirely different. Students from all three clusters demonstrated relatively similar abilities on the fluency and flexibility indicators, while differences were more apparent on the elaboration and originality indicators, particularly in terms of accuracy, the completeness of solution steps, and the ability to generate diverse models. These findings support the correlation results indicating that the relationship between conceptual understanding and mathematical creative thinking is not uniform across all levels of students' conceptual understanding.

In line with Prihandhika & Azizah (2025) conceptual understanding that is still dominated by procedural and symbolic aspects does not necessarily translate into the ability to develop diverse representations and ideas. These findings are also supported by Hermawan et al. (2024), who demonstrated that students with low ability can still achieve certain indicators of creative thinking even if they do not meet all indicators. In this study, all clusters still exhibited limitations in the "originality" indicator, which requires the development of more diverse ideas and strategies. Additionally, some students still struggle with understanding problem information, modelling mathematical problems, and determining the final answer accurately. These findings align with those of Fineldi & Hidayati (2023) and Tamirrino et al. (2023) who state that problem comprehension and precision are related to the achievement of creative thinking skills. Therefore, mathematical

creative thinking is not only related to conceptual understanding but is also influenced by learning factors, affective factors, and student characteristics (Jaenudin, 2023).

Conclusion and Suggestion

Based on the research results, there is a significant positive correlation of moderate strength between students' prerequisite conceptual understanding and their mathematical creative thinking skills in junior high school regarding linear equations. However, after students were grouped using K-Means Clustering, this correlation was not significant across all clusters, although the strength of the correlation varied between clusters. Analysis of students' responses showed that the characteristics of mathematical creative thinking at each level of conceptual understanding were relatively similar in terms of the fluency and flexibility indicators, while differences were more apparent in the elaboration and originality indicators. These findings indicate that the relationship between conceptual understanding and mathematical creative thinking is not uniform across all levels of students' conceptual understanding.

These findings indicate that the relationship between conceptual understanding and mathematical creative thinking is not uniform across all levels of students' conceptual understanding. Therefore, mathematics instruction needs to provide students with opportunities to explore various problem-solving strategies and develop new ideas. However, this study is still limited to a single class and the topic of linear equations; thus, future research could involve a broader sample and different topics.

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