Jurnal Pijar MIPA
https://jurnalfkip.unram.ac.id/index.php/JPM
ISSN 1907-1744 (Print)
ISSN 2460-1500 (Online)

The Analysis of Students Creative Thinking Ability Using Mind Map on Solution Topic

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Received: October 6, 2025. Accepted: December 3, 2025. Published: December 8, 2025

Abstract: Creative thinking is one of the key competencies in 21st-century education. This study aimed to analyze students' creative thinking skills on the topic of solutions using mind maps as an assessment tool. This study used a quantitative descriptive method involving 44 XII-grade students from two senior high schools in Padang City during the 2025/2026 academic year. The instrument used was adapted from Rahayu et al., focusing on four indicators of creative thinking: fluency, flexibility, originality, and elaboration. The results showed that most students (95.45%) were categorized as less creative, while one student (2.27%) was creative, and one (2.27%) was not creative. No students achieved the highly creative level. The highest achievement was in the fluency aspect (86.36%), followed by flexibility (60.90%), originality (38.25%), and elaboration (19.88%). These findings indicate that students were relatively capable of generating ideas but struggled to develop and connect them in more original and detailed ways. This study highlights the novelty of using mind maps as an alternative assessment tool for measuring creative thinking in chemistry learning, specifically in the context of solutions, and suggests the need for creativity-oriented instructional approaches.

Keywords: Creative Thinking; Mind Map; Solution Topic.

Introduction

Creative thinking ability is an essential skill in the 21st century. The Organisation for Economic Co-operation and Development (OECD) has identified creativity as one of the key goals of 21st-century learning. Similarly, the Profil Pelajar Pancasila in the Merdeka Curriculum emphasizes the development of creativity as a crucial competency. Deep Learning, which has become a central focus of Indonesia's current educational framework, also highlights creative ability as an important dimension of student learning outcomes.

The demand to cultivate students with creative thinking skills is crucial for preparing them to address global challenges, particularly in solving complex and unfamiliar problems. Creative thinking refers to the ability to generate new and different concepts, solutions, or ideas [1]. Individuals with creative ability possess the capacity to produce a wide range of ideas, manipulate them in unconventional ways, and establish meaningful connections to develop new, effective, and engaging solutions to achieve specific goals [2]. Creative ability is not an innate talent but can be developed in every individual to varying degrees. Therefore, creative thinking can be nurtured and enhanced through appropriate learning experiences. The aspects of creative thinking include fluency, flexibility, originality, and elaboration [3].

Creativity plays an important role in chemistry classrooms, it needs to be implemented in the learning process [4], including in the topic of solutions. This topic not only requires students to master fundamental concepts but also to connect them with real-life phenomena encountered in daily life.

Although creative thinking skills are essential for students, the 2022 Programme for International Student Assessment (PISA) conducted by the OECD revealed that Indonesian students have relatively low creative thinking skills. The 2022 PISA data show that only 31% of Indonesian students reached at least the basic proficiency level in creative thinking, which is significantly lower than the OECD average of 78%. Moreover, only 5% of Indonesian students were categorized as top performers in creative thinking, compared to 27% across OECD countries [5].

In general, creative thinking skills are often measured using essay-based instruments such as the Guilford Test, Comprehensive Scientific Creativity Assessment (C-SCA), Torrance Tests of Creative Thinking (TTCT), Scientific Creativity Structure Model (SCSM), and Creative Scientific Ability Test (C-SAT). However, essay tests have several weaknesses that can affect the results and reduce their reliability.

Mind mapping offers an alternative approach to address the limitations of essay-based assessments. Introduced by Buzan in 1974, the mind map method is effective in supporting memory retention by helping organize facts and ideas in a way that naturally engages the brain from the beginning [6]. Mind maps have the potential to serve as flexible assessment tools for understanding students' conceptual development and scientific ideas. They can also be used to encourage student learning in science and to guide curriculum planning and classroom practice [7]. Therefore, mind maps can serve as a medium through which students express their creativity, making them a valuable tool for assessing creative thinking skills. In addition, many relevant studies, such as those conducted by Hidayati et al [8] and Fatmawati [9], also analyzed students' creative thinking skills using mind maps. However, there are still a

How to Cite:
M. Wahyuni and F. Q. Aini, "The Analysis of Students Creative Thinking Ability Using Mind Map on Solution Topic", *J. Pijar.MIPA*, vol. 20, no. 7, pp. 1341–1346, Dec. 2025. https://doi.org/10.29303/jpm.v20i7.10379

few studies that measure students' creative thinking skills using mind maps in chemistry lessons, specifically the topic of solutions. Therefore, this research is necessary.

Research Methods

This study is descriptive research. Using this method, the researcher aims to describe or provide an overview of the research object based on data obtained from samples or populations in their natural condition [10]. The research sample consisted of 44 XII-grade students from two senior high schools in Padang City during the 2025/2026 academic year. Sample selection was carried out using random sampling techniques. The topic of the mind maps created by the students was Solutions.

Table 1. Creative Thinking Skills Assessment Rubric

Aspect	Criteria	Score
Main idea (central idea)	Write the main idea	1
	Place the main idea in the centre	1
Keyword	Give several answers/responses to each question that identify the quantity of keywords.	
	$X > 15$	4
	$10 < X \leq 15$	3
	$5 < X \leq 10$	2
	$0 < X \leq 5$	1
	Legible	
	$X > 75\%$	2
	$X < 75\%$	1
Color	$9 < X \leq 12$	4
	$6 < X \leq 9$	3
	$3 < X \leq 6$	2
	$0 < X \leq 3$	1
Branches	The branch is curved or wavy	1
	Radiant branching	1
	Use the same colour in the same hierarchy branching	1
	Use different color in the different hierarchy branches	1

This research employed an instrument developed by Rahayu et al [11], as presented in Table 1. The instrument was designed to assess students' creative thinking skills based on the mind maps they make. The assessment focuses on four indicators of creative thinking ability, namely fluency, flexibility, originality, and elaboration. In the study, students' mind maps were assessed using an evaluation rubric adapted from Rahayu et al. Each mind map received scores based on predetermined criteria in the rubric. The resulting scores were then processed using Microsoft Excel to calculate total scores, percentages, and category classifications, facilitating the interpretation of students' creative thinking performance.

Results and Discussion

Students' creative thinking was assessed based on the mind maps they created on the topic of solutions. Table 2 shows that the majority of XII-grade students from two schools in Padang City were categorized as almost not creative (95.45%). In addition, 2.27% of students were categorized as creative, 2.27% as not creative, and 0% as very creative. A mind map is one of the easiest ways to input and retrieve information from the brain. Moreover, it is a creative and effective note-taking method that literally maps out one's thoughts [6].

Table 2. Students' Creative Thinking Levels

Category	Number of Students
Not Creative	1
Almost Not Creative	42
Creative	1
Very Creative	0

Overall, the fluency aspect showed the highest level of achievement among students, with a percentage of 86.36%. The flexibility aspect followed with 60.90%, while the originality aspect reached 38.25%. Meanwhile, the elaboration aspect had the lowest average achievement, with a percentage of 19.88%.

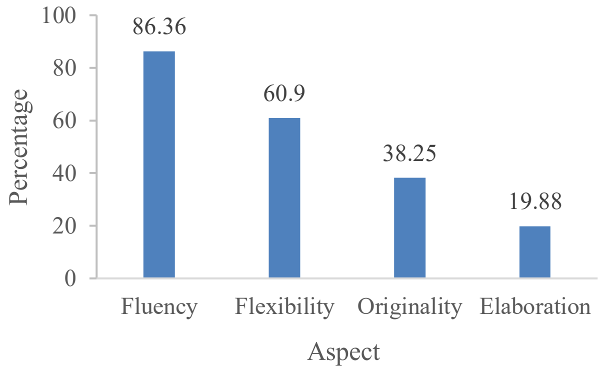

Figure 1. Students' Achievement Across Four Creative Thinking Aspects

Table 3. Number of Students with a Zero Score in Each Creative Thinking Aspect

Criteria	Number of Students with Zero Score
Fluency	
Main topic	7
Keywords	0
Color	0
Branch characteristics	7
Flexibility	
Basic order of ideas/BOIs	7
Number of branches (including BOIs)	0
Number of sub-branches	9
Originality	
Words	0
Illustration of the main idea	0
Illustration on sub-topics	34
Boundaries	44
Elaboration	
Hierarchy	0
Cross-link	44
Relations	44

The analysis stage began by sorting the students' mind maps. Each mind map was assessed using a scoring rubric to ensure it could be classified accordingly. Based on this assessment, several students received a score of zero in various criteria of creative thinking skills, as shown in Table 3.

Next, a categorization was conducted. In this process, the levels of each aspect of creative thinking skills were identified, as presented in Table 4.

Table 4. Number of Students Based on Scores and Levels of Creative Thinking in Each Mind Map Aspect

Aspect	Score	Level	Number of Students
Fluency	7	Almost Not Fluent	1
	10	Fluent	1
	11		1
	12		8
	13	Very Fluent	4
	14		8
	15		16
	16		5
Flexibility	4	Not Flexible	3
	6	Almost Not Flexible	6
	8		1
	10		2
	12	Flexible	3
	14		2
	16	Very Flexible	4
	18		2
	20		4
	26		2
	28		9
	30		6
Originality	6	Not Original	2
	9		7
	12	Almost Not Original	9
	15		16
	18		9
	21	Original	1
Elaboration	4	Not Elaborate	5
	8		20
	12		16
	16	Almost Not Elaborate	3

Students with low fluency demonstrated difficulties in placing the main idea at the center of the mind map and in using different colors for each hierarchical branch. These elements are essential because positioning the central idea in the middle allows ideas to expand naturally in all directions, reflecting the brain's radial and associative thinking. Meanwhile, the use of color supports idea grouping, memory enhancement, and focus.

In terms of flexibility, students faced greater challenges in creating sub-branches than in forming main branches (BOIs). Developing sub-branches requires expanding an idea from a previous one, which can be difficult for students accustomed to single-answer tasks. Sub-branches demand the ability to shift perspectives, a key indicator of cognitive flexibility.

In the originality aspect, none of the students achieved the "boundaries" criterion. Interview data indicated that students were capable of performing this task but lacked sufficient knowledge or motivation. Similar findings were observed in the elaboration aspect, particularly in cross-links and relations. These components are crucial because they demonstrate an understanding of interconceptual connections and the ability to integrate information into a meaningful network of ideas.

Students classified as "not creative" generally fell into the "low" categories of fluency and flexibility, were "not original" because they produced no new ideas, and were "not detailed" due to the absence of visible connections between ideas. In contrast, students categorized as "creative" were able to demonstrate originality by including illustrations in subtopics. These visual representations reflect a deeper conceptual understanding, unique expression, and the ability to creatively connect verbal and visual information. Although most students in the "less creative" category achieved fluency and flexibility, they did not reach the originality and elaboration aspects.

Fluency refers to the ability to think smoothly, meaning an individual's capacity to generate a large number of ideas. It reflects one's ability to produce many ideas by understanding the underlying concepts. Overall, the fluency aspect showed the highest level of achievement among students, with a percentage of 86.36%. This result is consistent with the findings of Satriah et al [12], which showed that the fluency aspect had the highest percentage, namely 74.22%. Having a high level of fluency indicates that students are capable of producing many ideas and demonstrating smooth thinking [13].

Figure 2. Example of a Mind Map with the Best Fluency Created by a Student

One of the criteria used to assess the fluency aspect is the number of keywords. The mind map shown in Figure 1 contains more than 15 keywords, where the main topic, Solutions, is divided into several relevant subtopics represented by keywords such as electrolyte solution, acid-base, concentration, buffer solution, mixture, and examples. However, there are also some subtopics and keywords that are not fully aligned with the main topic, such as colloid, types of colloids, and heterogeneous mixture. Fluency can also be evaluated from the use of colors and branches. In Figure 1, it can be seen that the student applied the same color within the same hierarchy and different colors for different hierarchies.

In contrast to Figure 1, Figure 2 shows a mind map with limited conceptual exploration. This is evident in the limited number of keywords generated, only five (concentration, colligative properties, boiling point elevation, vapor pressure lowering, and freezing point depression). After the subtopic concentration, the student appeared to struggle in generating further keywords. Whereas students who possess fluency will be able to generate many ideas [13]. Students who obtained low fluency scores tended to use keywords directly from the most recently learned material, such as colligative properties of solutions. This phenomenon suggests that students rely heavily on short-term memory when creating keywords. Short-term memory has a limited capacity and can only store information for a few seconds to minutes unless it is rehearsed or encoded into long-term memory [14]. The findings on the fluency aspect indicate that most students were able to identify the main topic and list relevant keywords in their mind maps. However, many students were still unable to use visual elements effectively, for instance, by applying varied colors to represent different hierarchies.

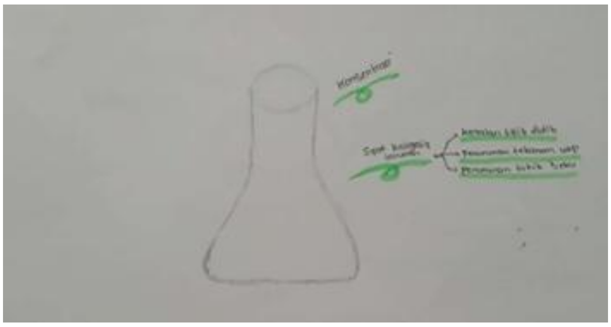

Figure 3. Example of a Mind Map with Low Fluency Created by a Student

The flexibility aspect is related to students' ability to view a problem from multiple perspectives and to construct idea branches in a varied manner. The results show that the criterion for main branches or the number of Basic Organizational Ideas (BOIs) achieved a higher percentage (62.12%) compared to the number of sub-branches, which only reached 46.02%. This suggests that students were generally capable of developing main idea branches but struggled to expand their ideas into more detailed levels. The limited development of sub-branches suggests that students are not yet accustomed to thinking flexibly and comprehensively, and they tend to stop at general or surface-level concepts.

Figure 3 shows a student with good flexibility. The student was able to create six main branches (BOIs), namely solution concentration, buffer solution, electrolyte solution, non-electrolyte solution, acid–base solution, and molality. From these six main branches, more than 12 sub-branches were generated. Individuals with a high level of flexibility can produce ideas based on various possibilities around them and view problems from different perspectives [15]. In contrast, Figure 4 shows a student who had difficulty developing appropriate BOIs, indicating a lack of flexibility in constructing relevant sub-branches.

Based on the students' mind maps, most students struggled to develop BOIs. The number of BOIs reflects the students' ability to identify subtopics related to the main topic. During interviews, several students reported finding it challenging to identify the appropriate BOIs. These findings suggest that students experienced difficulties in developing ideas flexibly and diversely. This is consistent with the results of other criteria, where the percentage of sub-branch achievement was only 46.02%. This limitation indicates that students are not yet accustomed to viewing a concept from multiple perspectives, resulting in mind maps that remain linear and simple.

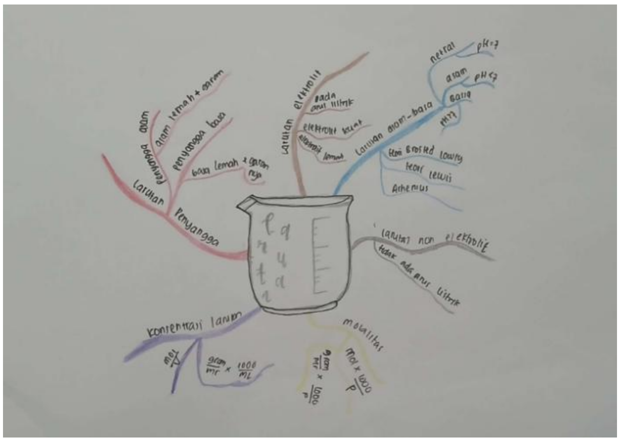

Figure 4. Example of a Mind Map with the Best Flexibility Created by a Student

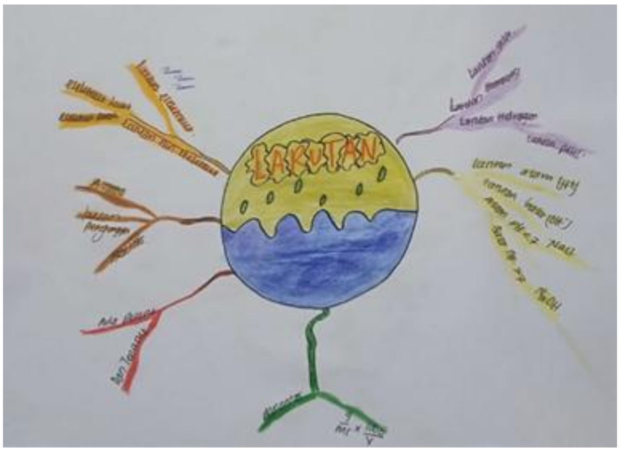

Figure 5. Example of a Student's Mind Map with Poor BOIs

The originality aspect reflects students' ability to generate unique and distinctive ideas. In this study, the criterion of illustration on the main topic achieved a 100% score, indicating that students were able to include simple symbols or drawings to represent the central idea. However, in terms of illustrating subtopics, most students struggled to create appropriate illustrations.

Figure 6. Example of a Student's Mind Map with the Best Originality

Figure 5 shows that the student was able to create appropriate illustrations for the keywords NaCl, homogeneous, soap, shampoo, and lemon. The selected images were relevant to the intended concepts, thereby helping to convey the message more effectively. Mind maps that incorporate colors and images can facilitate the transfer of information from short-term memory to long-term memory [16-18].

In the originality aspect, most students were only able to use simple words or basic illustrations, such as "appropriate illustration for the main topic" or "simple drawing for the central idea." However, the use of illustrations in subtopics was still minimal. Based on interview results, students were actually capable of creating relevant illustrations for subtopics, but most of them did not include these due to a lack of motivation. A similar situation was observed in the boundary criteria; none of the students added visual boundaries in their mind maps. However, when asked to create one during the interview, they were able to do so. Students explained that the absence of boundaries in their work was due to limited knowledge about this feature. This condition indicates that students were not yet accustomed to expressing uniqueness in their mind maps and tended to follow common patterns. Consequently, their level of original creativity remained low due to insufficient exploration of new ideas.

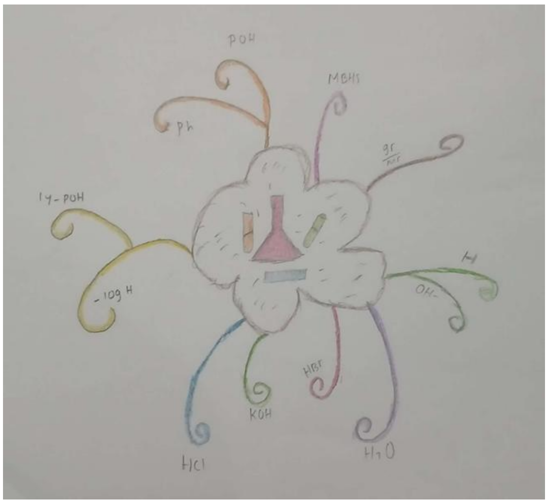

Figure 7. Example of a Student's Mind Map with Poor Hierarchical Level Criteria

The elaboration aspect was found to be the weakest among the four measured indicators. Only one criterion was achieved, the hierarchy level, with a percentage of 59.65%, while both cross-links and relations were not achieved at all (0%). This indicates that students were able to structure concepts from general to more detailed levels[19]. During the interviews, when students were asked to create cross-links and relations, they were actually able to do so. However, most admitted that they did not include them in their original mind maps due to a lack of motivation. In fact, cross-links and relations play an essential role in the elaboration aspect. Although students managed to develop hierarchical structures, their inability to connect ideas across different branches made their mind maps less comprehensive. This finding suggests that students were not yet accustomed to elaborating ideas by integrating concepts across branches. Yet, elaboration is a crucial indicator of creative thinking, as it reflects students' ability to organize the details of an idea and use existing information in the brain to perform a task [20-23].

Conclusion

Based on the results of the analysis of the creative thinking abilities of 44 students from two senior high schools in Padang City on the topic of solution, the majority of students were categorized as almost not creative (95.45%). In addition, 2.27% of students were categorized as creative, 2.27% as not creative, and 0% as very creative. None of the students reached the highly creative category. The aspects of creative thinking assessed through the mind map included fluency, flexibility, originality, and elaboration. Overall, the fluency aspect showed the highest level of achievement, with an average percentage of 86.36%. The flexibility aspect reached 60.90%, followed by originality at 38.25%. The elaboration aspect showed the lowest level of achievement, with an average percentage of 19.88%. Based on the results obtained, it is recommended that teachers use learning strategies that further improve students' creative thinking skills.

Author's Contribution

Melati Wahyuni: Developed the research design, conducted the research, analyzed the data, and finalized the writing of the scientific article. Faizah Qurrata Aini: Provided constructive suggestions for the perfection of the writing.

Acknowledgements

Throughout this research, I would like to express my deepest gratitude to my beloved family for their unwavering support, love, and encouragement. I am also sincerely grateful to my supervisors for their invaluable guidance, knowledge, and inspiration throughout the completion of this study. My heartfelt thanks also go to my colleagues in the Chemistry Education Study Program, who have been a constant source of motivation and inspiration.

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