JTC-RE: Journal of Tropical Chemistry Research and Education 7, 2 (2025): 120-133
Website: http://ejournal.uin-suka.ac.id/tarbiyah/index.php/jtcre
ISSN 2685-5690 **(online) ISSN** 2685-144X **(print)**

Analysis of Creative Thinking Skills of Senior High School Phase E Students through Mind Maps on The Subject Matter of The Nature of Chemistry

Munifa Mahdiah[1], Faizah Qurrata Aini[1*]

[1]Pendidikan Kimia, Fakultas Matematikan dan Ilmu Pengetahuan Alam, Universitas Negeri Padang, Padang, Indonesia
**E-mail: faizah_qurrata@fmipa.unp.ac.id*

ABSTRACT

The main problem in this study is the lack of analysis of students' creative thinking skills in chemistry learning, particularly in public high schools in Padang. Chemistry is often taught with an emphasis on memorization, so students rarely have the opportunity to develop creative thinking, essential for understanding abstract concepts and solving complex problems. This study aims to analyze the level of creative thinking skills of students in the topic of the nature of chemistry, reviewed in four aspects: fluency, flexibility, originality, and elaboration. The study employed a descriptive method with a quantitative approach, involving 40 students in phase E of SMAN Padang. Primary data were obtained from mind maps created by students and analyzed using assessment instruments. The results showed that fluency was the highest aspect (79.37%), followed by flexibility (75.00%), originality (60.55%), and elaboration (26.66%), which was the lowest. Based on the overall analysis, most students (29) were in the less creative category, 10 were categorized as creative, one as not creative, and none as very creative. These findings highlight that students still face challenges in elaborating and connecting chemical concepts, indicating the need for teaching strategies that promote higher-order and creative thinking. This study contributes to chemistry education by providing empirical evidence that can serve as a basis for developing instructional approaches to enhance students' creative thinking in learning chemistry.

Keywords: creative thinking; Essence of Chemistry; Mind Maps; Students in Phase E

DOI: https://doi.org/10.14421/jtcre.2025.72-05

1. INTRODUCTION

Deep learning-based learning strategies have become a significant topic of discussion in Indonesian education (Fullan et al., 2019). This initiative was proposed by the Ministry of Primary and Secondary Education (Kemendikdasmen), with the support of Prof. Abdul Mu'ti, as a strategic effort to improve the quality of national education (Khotimah & Abdan, 2025). This approach is based on four main components: graduate profile dimensions, learning principles, learning experiences, and learning frameworks (Akmal et al., 2025). Specifically, the graduate profile is defined in eight main competency dimensions that every student must master after completing their education, including: (1) faith and devotion to God Almighty, (2) active and responsible citizenship, (3) critical thinking, (4) creativity, (5) collaboration, (6) independence, (7) physical and mental health, and (8) practical communication skills (Mu'ti, 2025).

One of the expected graduate profiles here is to have high creativity. Creativity itself can be defined as the skill to generate new ideas applicable in solving problems, or as the capacity to see new connections between existing things (Munandar, 2009). In education, creativity does not always mean creating something completely new, but can also be the skill to combine existing ideas or concepts to produce something different from before (Crisvin et al., 2023). In addition, creative thinking skills are one of the important skills required in 21st-century learning (Pramudita et al., 2021). This is evidenced by including creative thinking skills indicators in one of the six dimensions of the Pancasila Student Profile contained in the independent curriculum (Mu'ti, 2025).

In school, chemistry requires creative thinking (Romayanti et al., 2020). The initial material students study in phase E is the nature of chemistry (Yulita, 2018). The nature of chemistry covers abstract concepts such as the structure, properties, and changes of matter and its scope and application in various fields of life. However, the complexity of this material is often presented theoretically without being linked to everyday reality, making it difficult for students to understand meaningfully.

According to the PISA (Programme for International Student Assessment) study results, Indonesia is among the 14 countries with the lowest scores in Creative Thinking (OECD, 2024). Data from The Global Creativity Index in 2023 also shows that Indonesia ranks 150th out of 160 countries (Florida & Mellander, 2023). This shows that students' creative thinking skills remain a challenge that needs to be addressed immediately. To improve creative thinking skills, the first step must be to determine the current level of creativity among students, so that teachers can determine the appropriate strategies, whether through the use of learning media, teaching methods, or other approaches (Kadir et al., 2022). There are many ways to measure creative thinking skills. However, in general, creative thinking skills are often measured using essay-type test instruments, such as the Guilford Test, the Comprehensive Scientific Creativity Assessment (CSCA) (Xu et al., 2024), Torrance Test of Creative Thinking (TTCT) (Alrubaie et al., 2014), the Scientific Creativity Structure Model (SCSM) (Hu & Adey, 2002), and the Creative Scientific Skills Test (C-SAT) (Sak & Ayas, 2013). However, essay tests have several weaknesses that can affect the results and reduce reliability. Some of the obstacles in essay tests include: (1) a more complex and time-consuming assessment process because it requires assessing the narrative of the students' answers, (2) the possibility of students giving irrelevant or convoluted answers, (3) the potential for errors in spelling and grammar, and (4) the existence of subjectivity in assessment (Waugh & Gronlund, 2013).

Mind mapping methods can be used as an alternative to overcome the weaknesses of essay tests. Mind maps have various functions, such as learning strategies, note-taking techniques, and media in the learning process (Rahayu et al., 2018; Mufidah, 2023). In addition, mind mapping can also be used as an assessment tool because it can measure creative thinking skills by following more flexible thinking patterns. This can be seen from research (Hidayati et al., 2023), which shows that Digital Mind Mapping (DMM) can identify students' creative thinking levels well. However, research that analyzes students' creative thinking skills in chemistry learning, especially in public high schools in Padang City, is still minimal. Many studies on mind maps focus on their effectiveness in improving creative thinking skills, while studies that emphasize measuring students' creative thinking skills are still minimal. In fact, assessing creative thinking skills is very important as an evaluation tool to determine the effectiveness of the learning strategies applied by teachers. With these measurements, teachers can obtain a clear picture of the development of students' creative thinking skills as an important indicator in the Pancasila Student Profile. Based on this, the research question in this study is: What is the level of creative thinking skills of phase E high school students through chemistry material in terms of fluency, flexibility, originality, and elaboration? In line with this, this study aims to analyze the level of creative thinking skills of phase E high school students in chemistry material in terms of fluency, flexibility, originality, and elaboration.

2. RESEARCH METHODS

This study uses a quantitative descriptive approach to obtain an overview of facts in the field without any intervention from the researcher (Sugiyono, 2015). This study has a descriptive research design with a quantitative approach and a research scheme adapted from (Niknejad et al., 2019), which includes the planning stage (problem formulation), the literature review stage, data collection stage (delivery of material on the nature of chemistry by subject teachers, followed by the creation of mind maps by students using equipment provided by the researcher), data analysis stage (scoring students' mind maps using a predetermined assessment instrument, then processing and interpreting the results), and conclusion drawing stage.

Table 1: Creative Thinking Skills Assessment Rubric

Aspect	Main Indicators	Score Range	Category
Fluency	• Main idea (central idea) • Number of keywords • Readability of keywords • Use of color and branching	0–16	0 – 4: Not Fluent 5 – 8: Almost Not Fluent 8 – 12: Fluent 13 – 16: Very Fluent
Flexibility	• Number of Basic Ordering Ideas (subtopics) • Number of main branches • Number of branching branches	0 - 20	0– 5: Not Flexible 6 – 10: Almost Not Flexible 11 – 15: Flexible 16 – 20: Very Flexible

Aspect	Main Indicators	Score Range	Category
Originality	• Use of unique words • Illustrations/images/symbols that represent concepts • Emphasis/marking (chunking) of important ideas	0 - 36	0 – 9: Not Original 10 – 18 : Almost Not Original 19 – 27 : Original 18 – 36: Very Original
Elaboration	• Depth of branch hierarchy (branching levels) • Relationships between hierarchies (cross-links) • Relationships within a hierarchy (relationships)	0 - 48	0 – 12: Not Elaborate 13 – 24: Almost Not Elaborate 25 – 36: Elaborate 37 – 48: Very Elaborate

Based on the assessment results, students' creative thinking skills were classified into four levels: not creative, barely creative, creative, and highly creative.

Table 2: Levels of creative thinking skills

Aspects of creative thinking skills				Points	Level	Category
***Fluency* (1)**	***Flexibility* (2)**	***Originality* (3)**	***Elaboration* (4)**			
-	-	-	-	0	Level 0	Not Creative
✓				1	Level 1	Almost Not Creative
	✓			2		
✓	✓			3		
		✓				
✓		✓		4		
			✓			
	✓	✓		5	Level 2	Creative
✓			✓			
✓	✓	✓		6		
	✓		✓			
✓	✓		✓	7		
		✓	✓			
✓		✓	✓	8		
	✓	✓	✓	9		

Aspects of creative thinking skills				**Points**	**Level**	**Category**
***Fluency* (1)**	***Flexibility* (2)**	***Originality* (3)**	***Elaboration* (4)**			
✓	✓	✓	✓	10	Level 3	Very Creative

3. RESULT AND DISCUSSION

The results of this study indicate variations in students' creative thinking abilities in the four aspects measured: fluency, flexibility, originality, and elaboration. Several influencing factors can explain these differences. First, learning motivation is central to creative performance; students with high intrinsic motivation tend to be more active in exploring and expressing ideas. This is in line with the findings of (Sari & Ristontowi, 2020) and (Anditiasari et al., 2021), which confirm that motivation significantly affects students' creative thinking abilities. Second, prior knowledge and conceptual understanding also determine the extent to which students can generate, categorize, and elaborate ideas; students with better mastery of chemistry concepts tend to be able to construct more meaningful and structured mind maps. These results are supported by (Mohammed & Al, 2025), (Adinda et al., 2022), and (Dewi et al., 2019), who all show that prior knowledge is closely related to the quality of learning outcomes, including in the context of mind map development.

1. Achievement of Fluency

The first aspect assessed in the mind mapping assessment rubric is fluency. This aspect consists of four criteria that are used as assessment indicators and are quantitative in nature (Rahayu et al., 2018). Four criteria are used as fluency benchmarks: central topic, keywords, color, and branches. All students' average mind mapping scores for each criterion are then converted into percentages, as shown in Figure 1 below.

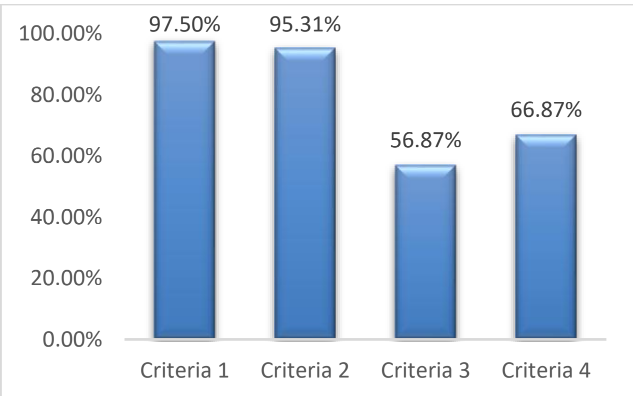

Figure 1. Achievement of Each Fluency Criteria

These results show that most students were able to meet Criteria 1 and Criteria 2 very well, while their achievement in Criteria 3 and Criteria 4 still needs to be improved. The following is a comparison of the mind map results of students who have a good level of proficiency and those who do not.

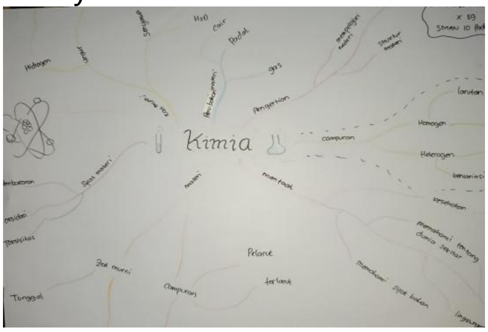

Figure 2. Mind map with excellent fluency

One indicator for assessing fluency is to count the number of keywords used. The mind map in Figure 2 contains more than 15 keywords, with one main topic, "The Nature of Chemistry," broken down into six subtopics: matter, properties of matter, benefits, changes in matter, mixtures, and pure substances. The main topic is placed at the center of the mind map, per the guidelines of (Rahayu et al., 2018)and (Rosba et al., 2021), which state that the main topic should be written in words and placed in the center. Each subtopic is linked to other keywords that form a hierarchy. In addition to their placement and number, the keywords created and the relationships between keywords, both within the same hierarchy and between different hierarchies, will be checked for accuracy. If a keyword is misspelled, it will not be counted.

Fluency is also reflected in the use of varying colors and branches, where the same color is used within the same hierarchy and different colors are applied to different hierarchies. The assessment covers four indicators in the branching criteria: branch shape, branching structure, color consistency in the same keyword branching, and color differences in different keyword branching. All of this is reflected in Figure 2.

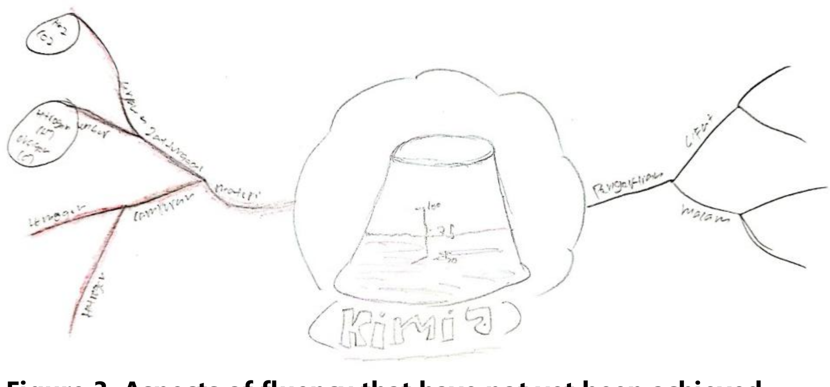

Figure 3. Aspects of fluency that have not yet been achieved

Figure 3 shows aspects of fluency that have not been achieved or fully explored, indicated by a few keywords (<15). The main topic was only broken down into two subtopics with poor readability. After writing these two subtopics, the students did not develop them further, indicating a limitation in connecting one keyword to another. Some keywords are also not suitable for being linked within a single hierarchy. Regarding the use of colour, the assessment indicators refer to the quantity and variety of colours used, including in images, symbols, and branch lines (Rahayu et al., 2018).In Figure 3, the colours used are not very varied, consisting of only two colours. Overall, the mind map in Figure 3 shows a low level of fluency.

2. Achievement of Flexibility

The flexibility aspect is assessed through three criteria: the placement of the basic topic order, the number of branches, and the number of sub-branches. The values of the three criteria are averaged, converted into percentages, and then presented in a figure.

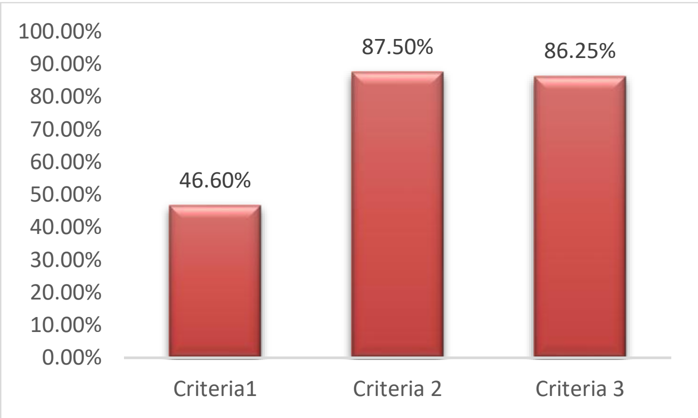

Figure 4. Achievement of Each Flexibility Criteria

This result indicates that students are more capable of meeting the criteria related to the overall number of branches, compared to the criteria for the basic topic order and the number of sub-branches, which are still in the low category.

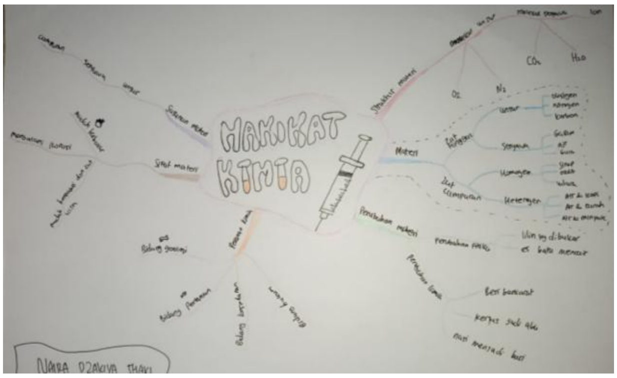

Figure 5. Example of Student Mind Map with Flexibility Aspect Achieved

A branch is a more specific concept derived from the main topic, while a sub-branch is a further breakdown of that branch. For example, the basic idea of "The Nature of Chemistry" has main branches of "matter" and "matter composition." The concept of "matter" is then broken down into "pure substances" and "mixtures." "Pure substances" are further divided into "elements" and "compounds"; these elements are further broken down into "oxygen," "nitrogen," and "carbon," while compounds are developed into "salt," "water," and "sugar."

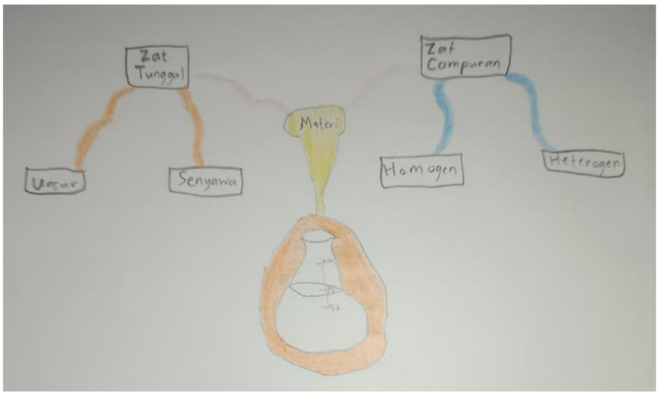

Figure 6. Example of Student Mind Map with Flexibility Aspect Not Yet Achieved

Although the mind map in Figure 6 has the same number of fundamental ideas (six BOIs), it does not show the development of advanced branches. This indicates that the flexibility aspect of the mind map has not been optimally fulfilled. While creating a mind map, students can refer to reading materials to determine the main concepts and keywords. This approach makes it easier for students to understand and remember the information they have read. This finding aligns with Buran & Filyukov's (2015)statement that recalling a few keywords from a text is far more effective than memorising the entire content of the text.

3. Achievement of the Originality Aspect

The third aspect of creative thinking skills measured in this study is originality. This aspect includes three criteria for evaluating students' mind mapping: word usage, illustrations, and boundary emphasis. The average percentage of student achievement for these three criteria is presented in the diagram below.

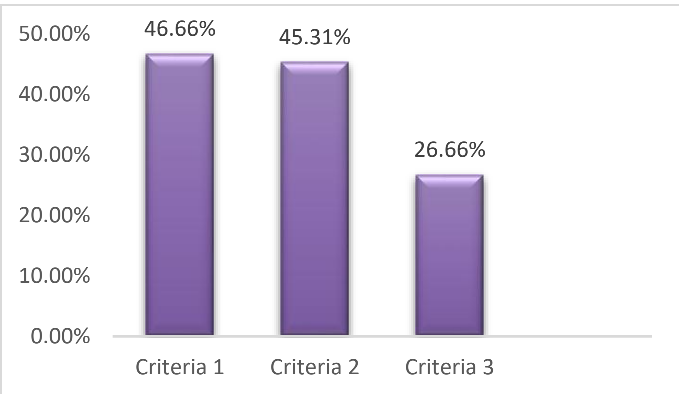

Figure 7. Achievement of Each Originality Criterion

This finding indicates a disparity between the originality criteria, where the achievement in Criterion 3 still lags far behind the other two criteria.

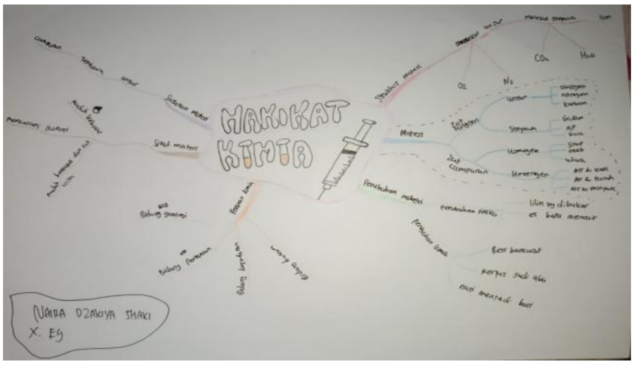

Figure 8. Example of Student Mind Map with Achieved Originality Aspect

Besides keyword relevance, the mind map in Figure 8 also has illustrations supporting concept representation. The illustration was chosen appropriately to visualise the idea, which can help learners understand and remember the message being conveyed. Illustrations can be images, symbols, or unique homemade visuals, as long as they do not contradict the basic concepts of chemistry. (D'antoni et al., 2010) Research shows that using colour and images in mind maps can facilitate the transfer of information from short-term to long-term memory. For example, in Figure 8, an image of an injection is shown for the main topic, and images of fire, bones, and fish are shown for the subtopics, all related to the concepts being discussed. Furthermore, the mind map also has visual boundaries that group important information into the same group. This law is marked by a circular line or a special line, and it serves as a marker for conclusions or the grouping of ideas, making it easier to store information in memory (Bystrova & Larionova, 2015). In Figure 8, the boundaries used are dashed lines to group closely related keywords.

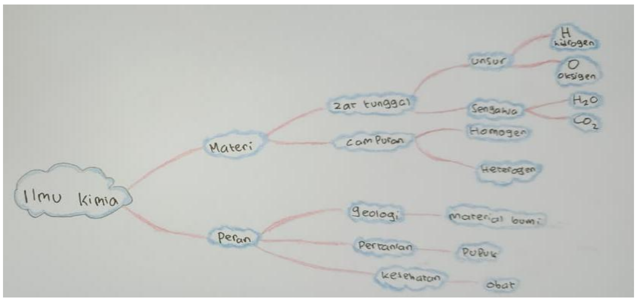

Figure 9. Example of Student Mind Map with Originality Aspect Not Yet Achieved

Unlike Figure 8, Figure 9 lacks originality. This is evident from the absence of illustrations for the main idea and subtopics, and the lack of dividers to group different concepts.

4. Achievement of the Elaboration Aspect

The aspect of elaboration was assessed using three criteria: hierarchy, relationships between the same hierarchies, and relationships between different hierarchies. The values for these three criteria were averaged, converted to percentages, and then presented in Diagram 10.

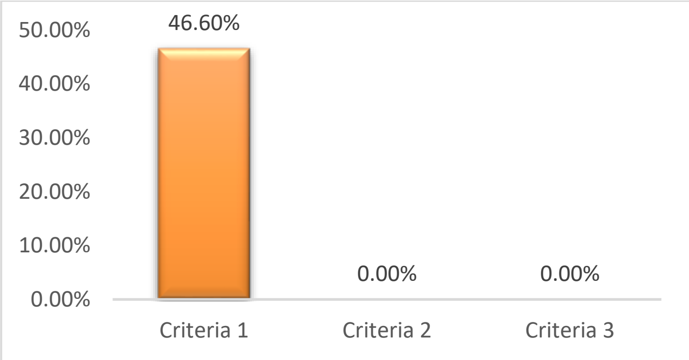

Figure 10. Achievement of Each Elaboration Criterion

These findings indicate that students are still struggling to meet the criteria for both same-level and different-level inter-hierarchical relationships, while their skills to construct basic hierarchies are beginning to emerge, although not yet optimally. In both the inter-data relationship (relation) and cross-linking criteria, student achievement was at its lowest point, 0%. This indicates that no students explicitly connected the relationships between concepts or keywords, whether within the same hierarchy or across different hierarchies. This finding is surprising, considering the confirmation results with the students indicated that they could associate one keyword with another. This finding was surprising, considering that confirmation with students indicated that they could link one keyword to another. However, these connections were not visually expressed during the mind map creation process.

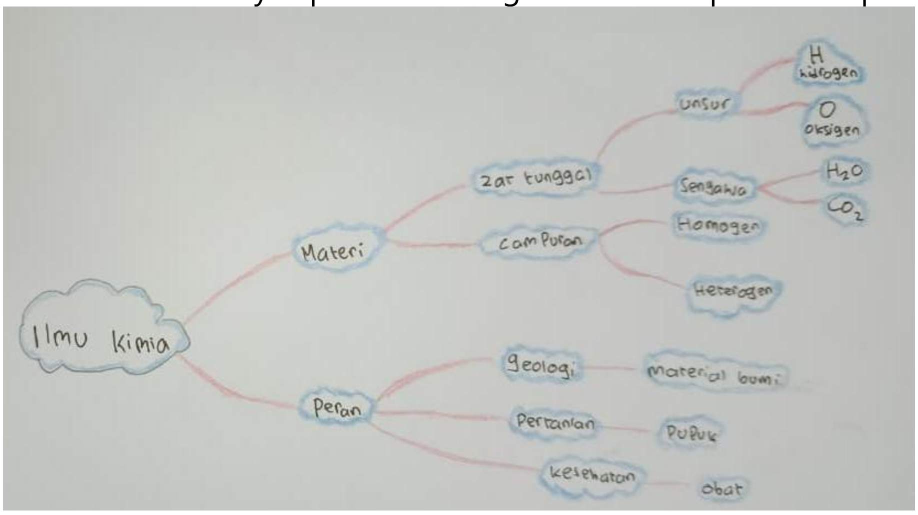

Figure 11. Example of a Student Mind Map with Elaboration Aspect Achieved but not yet fully

Analysis of mind maps that have met the assessment rubric shows the appropriate hierarchical placement in accordance with the material. For example, in the image, the main topic "The Nature of Chemistry" is placed at the highest position (level 0), then branches out into "Materials" as a level 1 topic. Next, "Single Substances" and 'Mixtures' are placed at level 2. At level 3, students elaborate on "Elements," "Compounds," "Homogeneous," and "Heterogeneous," while at level 4, the breakdown continues into concrete examples such as "Oxygen," "Nitrogen," "Carbon," "Salt," "Water," "Sugar," "Syrup," "Air," "Oral Rehydration Solution," "Water and Coffee," "Water and Soil," and "Water and Oil." The three mind maps have reached a level of detail of up to four hierarchical levels, which indicates a high level of depth of analysis. Conversely, regarding the criteria of data relations (relation) and cross-hierarchical relations (cross-linking), the students' achievements were at the lowest point, namely 0%. This indicates that no students connected the relationships between concepts or keywords within the same hierarchy or between different hierarchies.

5. Achievement of all Creative Thinking Aspects

The average percentage of the total score for each criterion in each aspect obtained by all students was then calculated and presented in the diagram below.

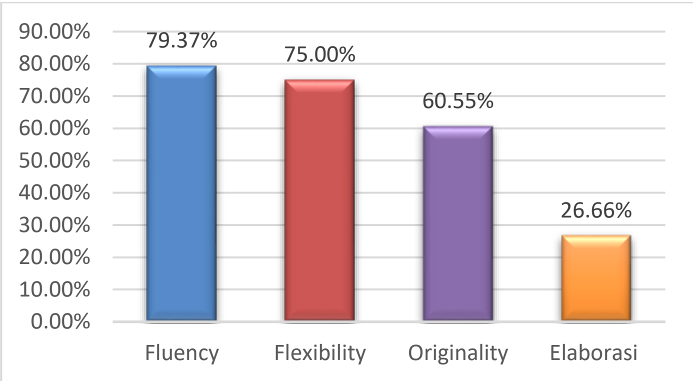

Figure 12. Achievement of the 4 Aspects of Creative Thinking Ability

This result indicates that students excel in generating ideas fluently and diversely, but still need improvement in their skills to elaborate on ideas in detail. After analysis, students' creative thinking skills can be categorised into four levels: not creative, less creative, creative, and very creative. The results of the students' creative thinking skills levels can be seen in the table below:

Table 3: Creative thinking skills

Category	Not Creative	Less Creative	Ctreative	Very Creative
Number of Students	1	29	10	0

4. CONCLUSION

This study concludes that the creative thinking skills of high school students in Padang City, as measured through mind mapping, are still dominated by the less creative category (29 students). The highest achievement was in the aspects of fluency (79.37%) and flexibility (75.00%), while originality was at a moderate level (60.55%), and elaboration was the lowest (26.66%). These findings indicate that mind mapping effectively stimulates the ability to generate and group ideas, but is still less than optimal in encouraging students to develop originality and deep conceptual connections. In chemistry learning, this condition implies the need for teaching strategies that emphasize strengthening elaboration and originality so that students' creative thinking skills develop more evenly.

REFERENCES

Adinda, A., Ajda, K. H., Purnomo, H., & Zulhamdi, Z. (2022). Mapping Prior Knowledge Middle Students in Solving Arithmatics Problems. *Logaritma : Jurnal Ilmu-Ilmu Pendidikan Dan Sains*, *10*(2), 165–180. https://doi.org/10.24952/logaritma.v10i2.6153

Akmal, A. N., Maelasari, N., Ilmu, T., & Islam, P. (2025). *Pemahaman Deep Learning dalam Pendidikan : Analisis Literatur melalui Metode Systematic Literature Review (SLR) [Understanding Deep Learning in Education: Literature Analysis through the Systematic Literature Review (SLR) Method]. 8.*

Alrubaie, F., Gnanamalar, E., & Daniel, S. (2014). Developing a Creative Thinking Test for Iraqi Physics Students. In *International Journal of Mathematics and Physical Sciences Research* (Vol. 2). Online. https://www.researchgate.net/publication/380317186

Anditiasari, N., Pujiastu, E., & Susilo, B. E. (2021). Systematic literature review: pengaruh motivasi terhadap kemampuan berpikir kreatif matematis siswa. *Jurnal Matematika Dan Pendidikan Matematika* , *12*(2), 236–248.

Buran, A., & Filyukov, A. (2015). Mind Mapping Technique in Language Learning. *Procedia - Social and Behavioral Sciences*, *206*, 215–218. https://doi.org/10.1016/j.sbspro.2015.10.010

Bystrova, T., & Larionova, V. (2015). Use of Virtual Mind Mapping to Effectively Organise the Project Activities of Students at the University. *Procedia - Social and Behavioral Sciences*, *214*, 465–472. https://doi.org/10.1016/j.sbspro.2015.11.724

Crisvin., Asbari, Masduki., & Chiam, J. Valencia. (2023). Innovate to Liberate: Akselerasi Kreativitas Siswa dalam Pendidikan. *Journal of Information Systems and Management (JISMA)*, *2*(5), 8–12.

D'antoni, A. V, Pinto Zipp, G., Olson, V. G., & Cahill, T. F. (2010). *Does the mind map learning strategy facilitate information retrieval and critical thinking in medical students?* http://www.biomedcentral.com/1472-6920/10/61

Dewi, S. P., Zen, D., & Haryani, M. E. (2019). Prior Knowledge Mapping on Teacher Candidates for Reproductive System Material in UNSRI. *Journal of Biology Education*, *8*(1), 117–125.

Florida, R., & Mellander, C. (2023). *The Global Creativity Index: National Creativity Ecosystems and Their Relationship to Economic Development and Inequality* (pp. 173–196). https://doi.org/10.1007/978-3-031-33961-5_10

Fullan, M., Quinn, J., & Mceachen, J. (2019). Book Review: Deep Learning: Engage the World Change the World. *Journal of Catholic Education*, 122–127. https://doi.org/10.15365/joce.2202082019

Hidayati, N., Fitriani, A., Saputri, W., & Ferazona, S. (2023). Exploring University Students' Creative Thinking Through Digital Mind Maps. *Journal of Turkish Science Education*, *20*(1), 119–135. https://doi.org/10.36681/tused.2023.007

Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24*(4), 389–403. https://doi.org/10.1080/09500690110098912

Kadir, I. A., Machmud, T., Usman, K., & Katili, N. (2022). Analisis Kemampuan Berpikir Kreatif Matematis Siswa Pada Materi Segitiga. *Jambura Journal of Mathematics Education*, *3*(2), 128–138. https://doi.org/10.34312/jmathedu.v3i2.16388

Khotimah, D. K., & Abdan, M. R. (2025). Analisis Pendekatan Deep Learning untuk Meningkatkan Efektivitas Pembelajaran PAI di SMKN Pringkuku. *Jurnal Pendidikan Dan Pembelajaran Indonesia (JPPI)*, *5*(2), 866–879. https://doi.org/10.53299/jppi.v5i2.1466

Mohammed, A., & Al, B. (2025). *Effectiveness of Mind-Mapping in Activating University Students ' Prior Knowledge to Enhance Learning and Comprehension*. 280–296.

Mufidah, A. (2023). *Melalui Mind Mapping Pada Materi Hidrolisis*. Universitas Islam Negeri Syarif Hidyatullah.

Mu'ti, A. (2025). *Pembelajaran Mendalam Menuju Pendidikan Bermutu Untuk Semua* (M. Yusro, Ed.). Pusat Kurikulum dan Pembelajaran Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan Dasar dan Menengah Republik Indonesia.

Munandar, U. (2004). Mengembangkan Bakat dan Kreativitas Anak Sekolah. Jakarta: PT Gramedia.

Niknejad, N., Hussin, A. R. C., & Amiri, I. S. (2019). *The Impact of Service Oriented Architecture Adoption on Organizations*. Springer International Publishing. https://doi.org/10.1007/978-3-030-12100-6

OECD. (2024). *PISA 2022 Results (Volume III): Vol. III*. OECD. https://doi.org/10.1787/765ee8c2-en

Pramudita, I. F. E., Praherdhiono, H., & Adi, E. P. (2021). Studi Keterampilan Abad 21 Mahasiswa Dalam Memilih Peminatan. *JKTP: Jurnal Kajian Teknologi Pendidikan*, *4*(3), 251–259. https://doi.org/10.17977/um038v4i32021p251

Rahayu, P., Susantini, E., & Oka, D. N. (2018). Development of Creative Mind Map Rubric to Assess Creative Thinking Skills in Biology for the Concept of Environmental Change. In *International Journal of Innovation and Research in Educational Sciences* (Vol. 5, Issue 2).

Romayanti, C., Sundaryono, A., & Handayani, D. (2020). Pengembangan E-Modul Kimia Berbasis Kemampuan Berpikir Kreatif Dengan Menggunakan Kvisoft Flipbook Maker. *Alotrop*, *4*(1). https://doi.org/10.33369/atp.v4i1.13709

Rosba, E., Zubaidah, S., Mahanal, S., & Sulisetijono, S. (2021). Digital Mind Map Assisted Group Investigation Learning for College Students' Creativity. *International Journal of Interactive Mobile Technologies*, *15*(5), 4–23. https://doi.org/10.3991/ijim.v15i05.18703

Sak, U., & Ayas, M. B. (2013). *Article in Psychological Test and Assessment Modeling*. https://www.researchgate.net/publication/264671229

Sari, E. N., & Ristontowi. (2020). Pengaruh Motivasi Belajar Terhadap Kemampuan Berpikir Kreatif Matematis Siswa dalam Model Problem Based Learning (PBL) di SMP. *Jurnal Pendidikan Matematika Raflesia*, *05*(03), 54–62.

Sugiyono. (2015). *Metode Penelitian Pendidikan* (22nd ed.). Alfabeta.

Waugh, C. K., & Gronlund, N. E. (2013). *Assessment Of Student Achievement* (Jeffery W. Johnston, Ed.; 10th ed.). Pearson.

Xu, S., Reiss, M. J., & Lodge, W. (2024). Comprehensive Scientific Creativity Assessment (C-SCA): A New Approach for Measuring Scientific Creativity in Secondary School Students. *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-024-10469-z

Yulita, I. (2018). Analisis Prekonsepsi Siswa Terhadap Kemampuan Menghubungkan Konteks Air Laut Dengan Konten Hakikat Ilmu Kimia Kelas X Sma. *Jurnal Pendidikan Sains (JPS)*, *06*(01), 64–72. http://jurnal.unimus.ac.id/index.php/JPKIMIA%0AANALISIS