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MATHEMATICAL MIND MAPPING ABILITY OF SENIOR HIGH SCHOOL STUDENTS IN PALEMBANG CITY

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Abstract

Mind mapping is considered an effective visualization strategy for improving conceptual understanding in mathematics. However, little is known about students' ability to construct mathematical mind maps. This study aimed to describe the mathematical mind-mapping ability of senior high school students in Palembang City. A descriptive quantitative design was employed by using *voluntary/convenience sampling*, 90 senior high school students from public and private schools in Palembang participated in the study. Data were collected through Google Forms using a mathematical mind-mapping task and assessed using a rubric adapted from Tony Buzan's mind-mapping criteria consisting of central image, branching structure, keywords, colours, images, and hierarchy. The rubric was reviewed by two mathematics education experts to establish content validity and scored independently. Of the 90 submitted mind maps, only 34 met the predefined assessment criteria and were included in the scoring analysis. The analysed 34 mind maps obtained an average score of 33.67, which falls into the poor category. The findings suggest that explicit instruction and continuous practice in mathematical mind mapping should be integrated into classroom learning.

Keywords: ability, mind mapping, visualization, mathematics, Palembang

INTRODUCTION

One of the skills an educator must possess is designing an active learning environment that engages students enthusiastically. However, most educators still prefer conventional learning methods, which can lead to student disengagement (Hanifah, 2023). Collaboration skills are becoming increasingly important for students to solve complex problems effectively in the 21st-century learning era, so a well-structured visual approach can accelerate the discovery of effective, efficient solutions (Salim et al., 2024).

The mind-mapping-based inquiry learning model is considered to make a major contribution to teachers in developing students' thinking skills in learning (Nur et al., 2024). Mind mapping is a visual tool that helps organize information, enhance creativity, and improve memory by using a radial structure that starts from a central concept and branches out to related subtopics (Spencer et al., 2013) using colors, images, and keywords to create a visually appealing and easy-to-understand representation of information (Edwards & Cooper, 2010; Le et al., 2023).

Mind mapping also helps transform abstract, invisible thoughts into a visible, structured format, making it easier for students to understand complex concepts (Liu et al., 2018; Wenchao et al., 2018; Zheng et al., 2025). This learning model helps improve understanding information by creating logical connections between concepts (Swestyani et al., 2018).

This technique encourages holistic thinking, balancing logical and imaginative thinking, thereby enhancing creative problem-solving abilities (Jianxin Chen, 2008; O'Connell, 2016). This supports active learning strategies, which are more effective than traditional passive learning methods (Wu & Frost, 2025). While students often copy notes directly from textbooks, many still take lengthy, linear notes without variation. This linear, ineffective, and inefficient note-taking hinders the achievement of optimal learning outcomes (Jayanti et al., 2023).

Research (Jumri et al., 2024) shows that mind mapping has a positive influence on

the conceptual understanding of grade XI students of SMA N 6 Kota Bengkulu. The results showed that the mind-mapping group demonstrated a significant increase in conceptual understanding compared to the control group, as evidenced by a higher post-test score of 8.85 points. The importance of mind mapping as a learning tool is that it allows students to organize information, form relationships between concepts, and visualize mathematical material more easily. Students who engage in mind mapping tend to develop a deeper understanding which is reflected in improved post-test scores. These findings are expected to encourage educators to integrate mind mapping into teaching strategies to improve the effectiveness of mathematics teaching and students' conceptual understanding.

Therefore, further investigation is warranted, given the importance of mind mapping as a tool for developing 21st-century skills. Mind mapping, as one form of visual mapping closely related to concept mapping, has been shown to support meaningful learning, knowledge organization, and higher-order thinking skills (Barta et al., 2022). Mind mapping has also been shown to increase student engagement and motivation in learning through an interactive and engaging visual approach. However, in practice, the implementation of mind mapping in schools still faces various challenges. Research shows inconsistent results regarding the impact of mind mapping on writing clarity and overall learning outcomes, suggesting that its benefits may depend on individual student skills and instructional context. Furthermore, limited literacy skills can hinder students' ability to use mind maps effectively for tasks such as writing or reading comprehension. For example, students with lower linguistic intelligence or prior knowledge may struggle to use mind maps effectively compared to their peers (Sefriyanti et al., 2021; Widiastuti et al., 2024).

Research on mind mapping in Palembang City over the last five years has been conducted by (Samaya & Suryadi, 2020), (Oktaningrum et al., 2022),(Apriana & Mulyati, 2020), (Gumay et al., 2024), and (Tampubolon et al., 2023). Previous studies have primarily investigated the effectiveness of mind mapping as a teaching strategy. However, limited studies have specifically examined students' actual ability to construct mathematical mind maps before instructional intervention, particularly among senior high school students in Palembang.

Considering the importance of mind mapping in supporting mathematics learning and the challenges still faced in its implementation, therefore, this study aims to describe the ability of high school students in Palembang City to create mathematical mind maps, and provide strategic recommendations for improving the application of mind mapping in mathematics learning at the high school level. Thus, this research is expected to contribute to the development of innovative learning strategies that are not only effective in improving the understanding of mathematical concepts but also equip students with creative thinking skills that are much needed in the 21st century.

Unlike previous studies that mainly investigated the effectiveness of mind mapping interventions, this study focuses on describing students' existing mathematical mind-mapping ability using standardized assessment criteria. The findings are expected to provide baseline information for designing visualization-based mathematics instruction in Indonesian secondary schools.

METHOD

This study employed a descriptive quantitative research design to describe senior high school students' ability to construct mathematical mind maps. A descriptive quantitative approach was selected because the primary objective of the study was to measure and describe students' mind-mapping abilities based on predetermined assessment criteria without manipulating any research variables. Using this approach, researchers can explore relationships among variables, identify patterns, and make strong generalizations to support their findings (Rachman et al., 2024).

This study was conducted from March 22 to April 22, 2024, at several accredited public and private high schools in Palembang City, South Sumatra, Indonesia. The target

population consisted of high school students in grades 10, 11, and 12. Participants were recruited through mathematics teachers at participating schools by distributing a Google Form containing research information and a mind mapping task. Participation was voluntary, and only students who agreed to participate and completed the assigned task were included in the study. A total of 90 students participated: 31 from grade 10, 28 from grade 11, and 31 from grade 12. The distribution of participants from each school is presented in Table 1.

Table 1. Research Subject Information

School Name	Accreditation	Grade/Class	Number of Students in Each Class	Number of Students
SMA Negeri 3 Palembang	A	X	1	3
		XII	3	
SMA Negeri 5 Palembang	A	X	1	2
		XII	1	
SMA Negeri 6 Palembang	A	XI	2	3
		XII	1	
SMA Negeri 8 Palembang	A	XI	2	2
SMA Negeri 11 Palembang	A	XII	3	3
SMA Negeri 14 Palembang	A	X	2	5
		XI	1	
		XII	2	
SMA Negeri 16 Palembang	A	X	1	8
		XI	7	
SMA Negeri 18 Palembang	A	X	6	10
		XI	1	
		XII	3	
SMA IBA Palembang	A	XI	2	3
		XII	1	
SMA LTI IGM Palembang	A	XII	2	2
MAN 2 Palembang	A	X	1	4
		XII	3	
MAN 3 Palembang	A	X	7	9
		XI	1	
		XII	1	
SMA Mandiri Palembang	B	X	1	4
		XI	3	
SMA Muh 1 Palembang	A	X	1	5
		XI	2	
		XII	2	
SMA Nurul Amal Palembang	A	X	3	3
SMA Nurul Iman Palembang	A	X	3	4
		XI	1	
SMA PGRI 4 Palembang	B	X	4	10
		XII	6	
SMA Pusri Palembang	A	XI	4	4
SMA Taman Siswa Palembang	A	XII	3	3
SMA YWKA Palembang	A	XI	1	2
		XII	1	
Total				**90**

Data were collected using two research instruments: (1) a math mind map assignment guide and (2) a math mind map assessment rubric. The assignment guide instructed students to create a math mind map based on a math topic they had learned while adhering to basic mind map principles. Students were instructed to include a central figure, curving branches, keywords, colors, images or symbols, and hierarchical relationships between concepts.

The assessment rubric was developed based on the mind map principles proposed by Tony Buzan (Windura, 2016). The rubric evaluated several indicators, including the presence of a central figure, branching structure, use of keywords, use of colors and images, organization of ideas, and the overall quality of the mind map. Before use in this study, the rubric was reviewed by two mathematics education identify factors that influence these abilities to ensure that the assessment indicators were relevant, clear, and appropriate for measuring students' math mind map creation skills. Revisions to the rubric were made based on the experts' recommendations prior to data collection.

Data collection was conducted online via Google Forms throughout the study period. Students first filled in their demographic information and then uploaded their math mind maps. After all submissions were received, each mind map was screened to determine whether it met the minimum structural characteristics of a standard mind map based on Tony Buzan's principles. These minimum requirements include the presence of a central image, a branching structure, curving branches, and the use of keywords. Mind maps that did not meet these minimum structural requirements were excluded from the detailed assessment process because the established rubric was designed to assess complete mind maps. Of the 90 submitted mind maps, 34 met the assessment criteria and were subsequently evaluated using the complete assessment rubric, while the remaining submissions were analyzed descriptively to identify the most common errors in student mind map creation.

The researchers assessed the students' mind maps using the established assessment rubric. To maintain consistency in assessment, each indicator was evaluated according to predetermined scoring guidelines developed in conjunction with the assessment rubric. The collected data were analyzed using descriptive statistics, including frequencies, percentages, means, and category distributions, to illustrate students' mathematical mind mapping abilities. Furthermore, descriptive comparisons were conducted across grades 10, 11, and 12 to identify differences in student performance and to determine the most common weaknesses found in each assessment indicator.

Prior to data collection, the math mind map assessment rubric underwent a content validation process to ensure that the assessment indicators accurately represented the essential components of a math mind map. The rubric was reviewed by two mathematics education experts who evaluated the rubric based on the relevance, clarity, completeness, and appropriateness of each assessment indicator to measure students' math mind map abilities.

The validation process focused on the indicators' alignment with the theoretical principles of mind maps proposed by Tony Buzan, including the use of central images, branching structures, keywords, visual elements, hierarchical organization, and overall presentation. The experts also assessed the clarity of the assessment criteria to ensure that each performance level could be interpreted consistently throughout the assessment process. The experts' suggestions were incorporated into the final version of the rubric before use in data collection.

RESULT AND DISCUSSION

A total of 90 mathematical mind maps were submitted by students during the data collection period. Before conducting the scoring process, all submissions were screened using the minimum structural requirements of a standard mind map based on Tony Buzan's principles. These requirements included the presence of a central image, curved branching structure, keywords, visual elements, and hierarchical organization of ideas.

The screening results indicated that

only 34 of the 90 submitted mind maps fulfilled the minimum assessment requirements and could therefore be evaluated using the assessment rubric. The remaining 56 submissions were excluded from rubric-based scoring because they lacked one or more essential structural components, making them unsuitable for consistent evaluation. Although these submissions were excluded from the scoring process, they were further examined descriptively to identify the most common deficiencies in students' mathematical mind maps. The distribution of scores for the students whose work was analyzed is shown in Figure 1.

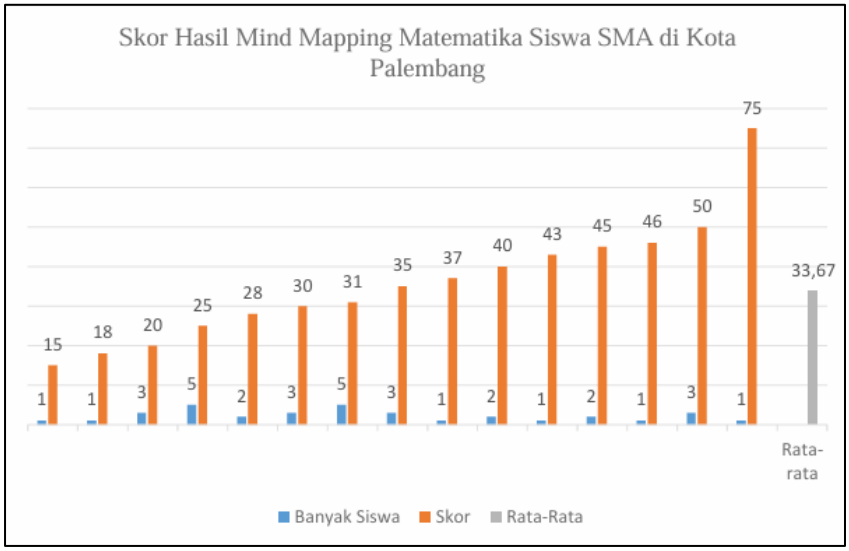


Figure 1. Mathematics Mind Mapping Score Graph for High School Students in Palembang

Descriptive statistical analysis was conducted on the 34 mind maps that met the assessment criteria. The average mathematical mind-mapping score was 33.67, indicating that students' mathematical mind-mapping ability was generally categorized as Poor. The distribution of students across performance categories is presented in Table 2.

Table 2. Overall Mind Mapping Score Analysis Results

Class	Number of Mind Maps Analysable	Average Score	Category
X	10	29.60	Poor
XI	13	35.38	Poor
XII	11	34.54	Poor

The average scores obtained by students in Grades X, XI, and XII were 29.6, 35.38, and 34.54, respectively. Although Grade XI obtained the highest average score, all three grade levels remained within the Poor performance category. These findings indicate that students' mathematical mind-mapping ability was consistently low across different grade levels.

Table 3. Distribution of Unfulfilled Mathematical Mind-Mapping Assessment Indicators

Indicator	Number of Students	Percentage
Did not use keywords	17	50.0
Did not use curved branches	15	44.1
Used vertical page orientation	9	26.5
Did not include images	9	26.5
Did not use colours appropriately	8	23.5
Central image incomplete	7	20.6

Table 3 presents students' performance for each assessment indicator. The most frequently observed deficiency was the absence of keywords, which occurred in 17 of the 34 assessed mind maps (50.0%). Keywords are one of the essential characteristics of mind mapping because they facilitate concise representation of concepts. Another common weakness was the absence of curved branches, identified in 15 mind maps (44.1%). Several students also constructed their mind maps using a vertical page orientation rather than the recommended horizontal layout (26.5%), while others omitted images and colour variations that support visual organization of information. These findings indicate that many students were able to identify mathematical concepts but had difficulty applying the structural principles of an effective mind map.

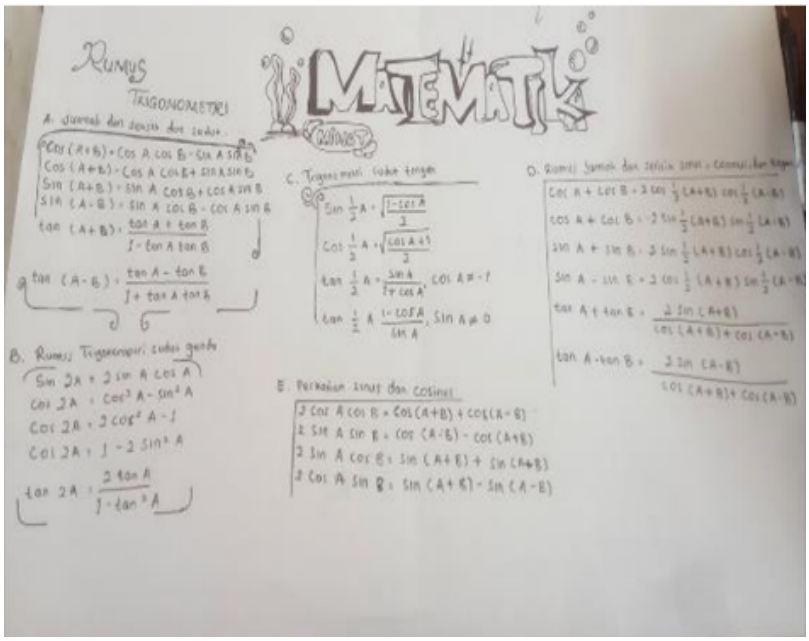


Figure 2. Mind Mapping Sample Does Not Meet Criteria

Figure 2 illustrates examples of students' mathematical mind maps representing different levels of performance. The low-scoring mind map lacks several essential structural elements, including a central image, curved branches, and effective keyword usage. In contrast, the high-scoring mind map demonstrates a clear hierarchical structure, appropriate branching patterns, concise keywords, and the integration of colours and visual elements. These examples illustrate how adherence to mind-mapping principles contributes to higher assessment scores.

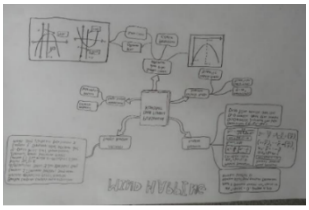
One of these samples was deemed not to meet this criterion because it lacked

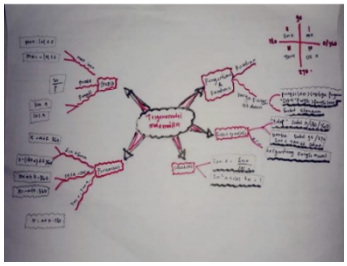
images. Images reinforce keywords in the mind map (Windura, 2016). In addition to lacking images, nine samples also did not meet the assessment criteria because their mind maps did not start from the center of the horizontal paper, but from the center of the vertical paper. Another 15 mind maps did not meet the criteria because they did not use curved-line branches. Good branches are organically shaped, tapering or narrowing at the ends and spreading out in all directions (Windura, 2016). Seventeen mind maps did not meet the keyword criteria.

Based on data analysis from 31 10th-grade high school students in Palembang City, 21 mind maps were deemed not to meet the criteria. Of the 28 mind maps from 11th-grade students in Palembang City, only 13 met the assessment criteria. Similarly, for 12th-grade students, only 11 out of 31 met the assessment criteria. To provide a clearer illustration of students' mathematical mind-mapping performance, examples of low- and high-scoring mind maps from each grade level are presented in Table 4. The comparison is intended to demonstrate how the fulfilment of the assessment indicators influenced students' scores.

As shown in Table 3, the differences between low- and high-scoring mind maps were primarily associated with the fulfilment of the assessment indicators rather than the amount of information presented. High-scoring mind maps consistently included a clear central image, hierarchical curved branches, concise keywords, appropriate colour variations, visual illustrations, and logical relationships among concepts. In contrast, low-scoring mind maps frequently omitted one or more of these essential components, particularly keywords, curved branches, and visual elements. These deficiencies reduced the effectiveness of concept organization and consequently resulted in lower assessment scores.

Table 4. Comparison of High and Low Score Mind Maps

	Low Score Mind Mapping	**High Score Mind Mapping**	**Main Characteristics Affecting the Score**
Class X			The low-scoring mind map lacked a clear central image, contained few keywords, used straight branches, and included limited colours and visual elements. In contrast, the high-scoring mind map demonstrated a well-defined central image, hierarchical curved branches, concise keywords, multiple colours, and supporting illustrations.
	Score = 10	Score = 50	
Class XI			The low-scoring mind map showed incomplete branching, repetitive text instead of keywords, and minimal visual organization. The high-scoring mind map displayed a logical hierarchy, effective keyword usage, appropriate colour coding, and interconnected concepts through curved branches.
	Score = 25	Score = 50	

Class XII			The low-scoring mind map lacked visual hierarchy and supporting images, while several concepts were connected without following standard mind-mapping principles. The high-scoring mind map fulfilled nearly all assessment indicators, including a prominent central image, hierarchical branching, keywords, colours, images, and balanced visual organization.
	Score = 20	Score = 75	

The present study found that senior high school students demonstrated a generally low level of mathematical mind-mapping ability, with an average score of 33.67. Across all grade levels, many students experienced difficulties in applying the essential principles of mind mapping, particularly the use of keywords, curved branches, central images, and visual elements. These findings suggest that although students were able to identify mathematical concepts, many experienced difficulties in organizing those concepts into a structured visual representation consistent with established mind-mapping principles.

The current findings are consistent with previous research by (Hammad et al., 2021) showing that visual mapping facilitates the organization of mathematical concepts and enhances conceptual understanding. However, students often struggle to establish meaningful visual connections between concepts when they are unfamiliar with mapping strategies. According to the principles of mind mapping, an effective mind map should contain a central image, hierarchical branches, keywords, colors, and visual illustrations that facilitate meaningful associations between concepts (Choudhari et al., 2021). These findings also support the view that constructing a mind map requires students to organize, connect, and monitor mathematical ideas rather than simply memorize information. Therefore, difficulties in applying mind mapping principles may reflect challenges in organizing mathematical thinking visually (Sain & Kusum, 2021). These similarities indicate that constructing an effective mathematical mind map requires not only conceptual understanding but also familiarity with visual organization strategies.

One possible explanation for these findings is that students may have had limited experience in applying formal mind-mapping principles during mathematics learning. However, because this study did not investigate classroom instructional practices or students' prior knowledge, this interpretation should be considered tentative.

Whereas previous studies have primarily examined the effectiveness of mind mapping as an instructional strategy, the present study provides empirical evidence regarding students' existing competence in constructing mathematical mind maps based on established assessment criteria. The findings provide baseline information regarding which aspects of mind mapping require greater instructional attention, particularly keyword selection, branching structure, and visual organization.

From an educational perspective, the findings indicate that mathematics teachers should explicitly introduce the structural principles of mind mapping before asking students to construct their own maps. Classroom instruction should provide opportunities for students to practice organizing concepts visually through the use of keywords, hierarchical branches, colours, and supporting images. Since the most common deficiencies were the absence of keywords and curved branches, classroom instruction should explicitly demonstrate how these structural elements contribute to

effective visual representation of mathematical concepts.

This study has several limitations. First, only mind maps that satisfied the minimum structural criteria were included in the detailed scoring process, which reduced the number of analyzed samples. Second, the study employed a descriptive quantitative design and therefore did not investigate the underlying factors influencing students' mind-mapping ability. Third, participants were recruited through voluntary participation, limiting the generalizability of the findings. Furthermore, the assessment focused on the quality of the completed mind maps and did not examine students' reasoning processes during mind-map construction.

Future studies are recommended to employ mixed-method or qualitative approaches involving classroom observations, interviews, and questionnaires to investigate how instructional practices, prior knowledge, and learning experiences influence students' mathematical mind-mapping ability. Experimental studies may also evaluate the effectiveness of explicit mind-mapping instruction in improving students' visualization skills. Future studies may also examine the relationship between students' conceptual understanding, spatial visualization skills, and mathematical mind-mapping ability.

CONCLUSION

This study described senior high school students' mathematical mind-mapping ability based on the fundamental principles of mind mapping. The findings revealed that students generally demonstrated a low level of mathematical mind-mapping ability, with an average score of 33.67. Across all grade levels, students experienced difficulties in applying several essential mind-mapping components, particularly keywords, curved branches, central images, and visual elements. These findings indicate that although students were able to represent mathematical concepts, many had difficulty organizing those concepts into a structured visual representation consistent with established mind-mapping principles.

This study contributes to the literature by providing an empirical description of students' ability to construct mathematical mind maps, an area that has received less attention than studies investigating mind mapping as an instructional strategy. The findings identify specific aspects of mind-map construction that require greater instructional support and may serve as baseline information for improving students' visual representation of mathematical concepts.

From an educational perspective, teachers are encouraged to provide explicit guidance and structured practice in constructing mathematical mind maps before using them as learning or assessment tools. Future research should investigate the instructional, cognitive, and contextual factors influencing students' mathematical mind-mapping ability using mixed-method or experimental approaches to obtain a more comprehensive understanding of the development of visual representation skills in mathematics learning.

REFERENCES

Apriana, A. A., & Mulyati, S. (2020). Pengaruh Model Pembelajaran Mind Mapping Terhadap Hasil Belajar Siswa Mata Pelajaran Sejarah Di Sma Negeri 8 Palembang. *Jurnal Muara Pendidikan*, *5*(1), 533–538. https://doi.org/10.52060/mp.v5i1.273

Barta, A., Fodor, L. A., Tamas, B., & Szamoskozi, I. (2022). The development of students critical thinking abilities and dispositions through the concept mapping learning method – A meta-analysis. *Educational Research Review*, *37*, 100481. https://doi.org/10.1016/j.edurev.2022.100481

Choudhari, S. G., Gaidhane, A. M., Desai, P., Srivastava, T., Mishra, V., & Zahiruddin, S. Q. (2021). Applying visual mapping techniques to promote learning in community-based medical education activities. *BMC Medical Education*, *21*(1), 210. https://doi.org/10.1186/s12909-021-02646-3

Edwards, S., & Cooper, N. (2010). Mind mapping as a teaching resource. *The Clinical Teacher*, *7*(4), 236–239.

https://doi.org/10.1111/j.1743-498X.2010.00395.x

Gumay, R., Arafat, Y., & Faipri Selegi, S. (2024). Pengaruh Literasi Digital Menggunakan Metode Pembelajaran Inovatif Berbasis Mind Mapping Pelajaran Bahasa Indonesia Kelas IV SD Negeri 79 Palembang. *Jurnal DIDIKA: Wahana Ilmiah Pendidikan Dasar*, *10*(2), 296–308. https://doi.org/10.29408/didika.v10i2.26894

Hammad, S., Dimitriadis, C., & Graham, T. (2021). Using Concepts Maps in a Foundation Mathematics Course: What Have we Learnt? *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(2), em1943. https://doi.org/10.29333/ejmste/9700

Hanifah, A. I. (2023). Pemanfaatan Mind Maping Untuk Meningkatkan Kreativitas Belajar Utilization of Mind Mapping to Increase Learning Creativity. *Jurnal Pengabdian Masyarakat Global*, *2*(1).

Jayanti, E. F., Choirudin, C., Anwar, M. S., Manivannan, R., & Saputra, J. A. (2023). How much does using the Mind Mapping learning approach "improve" the grasp of mathematical ideas in junior high school students? *Delta-Phi: Jurnal Pendidikan Matematika*, *1(1), 20–25*. https://doi.org/10.61650/dpjpm.v1i1.55

Jianxin Chen. (2008). The using of mind map in concept design. *2008 9th International Conference on Computer-Aided Industrial Design and Conceptual Design*, *1034–1037*. https://doi.org/10.1109/CAIDCD.2008.4730739

Jumri, R., Faras, H. R., & Ramadianti, W. (2024). Understanding mathematical concepts using the mind mapping learning model for high school students. *Union: Jurnal Ilmiah Pendidikan Matematika*, *12(2), 322–330*. https://doi.org/10.30738/union.v12i2.17516

Le, L.-A. T., Le, N. P., Ngo, L.-A. T., & Tran, Q.-N. T. (2023). The Use of Mind Mapping Technique in Descriptive Writing among Primary School Students. *Journal of Educational and Social Research*, *13*(4), 321. https://doi.org/10.36941/jesr-2023-0112

Liu, Y., Tong, Y., & Yang, Y. (2018). The Application of Mind Mapping into College Computer Programming Teaching. *Procedia Computer Science*, *129*, 66–70. https://doi.org/10.1016/j.procs.2018.03.047

Nur, J., Utami, S., Nuraini, H., & Kurniawan, A. (2024). Meta-analysis Influence of Integrated Mind Mapping Inquiry Based Learning Model on Student Problem Solving Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 116–123. https://doi.org/10.29303/jppipa.v10i3.6804

O'Connell, R. M. (2016). Mind Mapping for Critical Thinking. In *Leadership and Personnel Management* (2032–2055). IGI Global. https://doi.org/10.4018/978-1-4666-9624-2.ch091

Oktaningrum, N. A., Heldayani, E., & Selegi, S. F. (2022). Efektivitas Model Circ Berbantu Mind Mapping Terhadap Hasil Belajar IPS Kelas V SDN 91 Palembang. In *Innovative: Journal Of Social Science Research* (44).

Rachman, A., Yochanan, E., Samanlagi, A. I., & Purnomo, H. (2024). *Metode Penelitian Kuantitatif, Kualitatif dan R&D* (B. Ismaya, Ed.). CV Saba Jaya Publisher.

Sain, A., & Kusum. (2021). Mind Mapping: A Metacognitive Approach To Elevate Achievement In Mathematics Of Secondary School Students. *International Journal of Research - GRANTHAALAYAH*, *9*(7), 329–333. https://doi.org/10.29121/granthaalayah.v9.i7.2021.4115

Salim, F. A., Mahana, S., & Susanto, H. (2024). *Combining Problem-Based Learning and Collaborative Mind Mapping: A Strategy for Empowering Students' Collaboration Skills* (193–203). https://doi.org/10.2991/978-94-6463-624-6_16

Samaya, D., & Suryadi, E. (2020). Improving

Writing Skill of Research Proposal Through Mind Mapping of Economics Faculty Students of Tridinanti University Palembang. *Proceedings of the International Conference on Progressive Education (ICOPE 2019)*. https://doi.org/10.2991/assehr.k.200323.102

Sefriyanti, D., Syarifuddin, H., Arnawa, I. M., & Asmar, A. (2021). The effect of mind mapping on the concept comprehension abilities for grade x automotive student of vocational public schools in Sijunjung regency. *Journal of Physics: Conference Series*, *1742(1)*. https://doi.org/10.1088/1742-6596/1742/1/012047

Spencer, J. R., Anderson, K. M., & Ellis, K. K. (2013). Radiant Thinking and the Use of the Mind Map in Nurse Practitioner Education. *Journal of Nursing Education*, *52*(5), *291–293*. https://doi.org/10.3928/01484834-20130328-03

Swestyani, S., Masykuri, M., Prayitno, B. A., Rinanto, Y., & Widoretno, S. (2018). An analysis of logical thinking using mind mapping. *Journal of Physics: Conference Series*, *1022*, 012020. https://doi.org/10.1088/1742-6596/1022/1/012020

Tampubolon, A., Handayani, W., Guru Sekolah Dasar, P., & PGRI Palembang, U. (2023). Pengaruh Mind Mapping Terhadap Keterampilan Menulis Karangan Di Sd Negeri 24 Palembang. *Jurnal Ilmiah Pendidikan Dasar*, *8*(2). https://doi.org/https://doi.org/10.23969/jp.v8i2.9254

Wenchao, G., Ruijie, Z., Guoying, Z., & Xu, Q. (2018). Research on the Application of Mind Map in "Artificial Intelligence" Teaching. *Proceedings of the 2nd International Conference on E-Education, E-Business and E-Technology - ICEBT 2018*, *12–18*. https://doi.org/10.1145/3241748.3241754

Widiastuti, N. P. K., Putrayasa, I. B., Pujawan, I. G. N., & Widiana, I. W. (2024). Linguistic Intelligence: Improving Writing Ability through Mind Mapping of Project Based Learning. *International Journal of Language Education*, *8*(3). https://doi.org/10.26858/ijole.v8i3.66491

Windura, S. (2016). *Mind Map Langkah Demi Langkah*. PT Elex Media Komputindo.

Wu, X., & Frost, D. (2025). Fostering Engineering Enthusiasm and Inspiration: Engaging Through Collaborative Mind-Mapping. *2025 ASEE Annual Conference & Exposition Proceedings*. https://doi.org/10.18260/1-2--55865

Zheng, Q., Zuo, T., Liu, J., & Wu, J. (2025). Exploration and Application of Mind Maps in the Teaching of Electronic Technology Course. *2025 7th International Conference on Computer Science and Technologies in Education (CSTE)*, 783–787. https://doi.org/10.1109/CSTE64638.2025.11092294