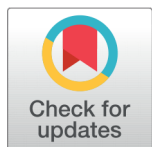


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Mind Mapping as a Strategy for Improving Students' Achievement in PISA-Type Mathematics Tasks: A Convergent Parallel Mixed-Methods Study

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Abstract

Objectives: This study examined the effectiveness of mind mapping in improving students' achievement in PISA-type mathematics tasks. **Method:** A convergent parallel mixed-methods design was employed involving 60 Grade 7 students from a public secondary school in Iloilo Province, Philippines. Using cluster random sampling, two intact classes were assigned to the experimental group (n = 30) and the control group (n = 30), which received mind mapping instruction and conventional instruction, respectively. Data were gathered using validated, teacher-developed contextualized mathematics assessments administered as pre-test and post-test measures before and after a 6-week intervention. **Findings:** Results revealed that both groups initially demonstrated low achievement levels (experimental: M = 24.48, SD = 6.72; control: M = 23.44, SD = 7.44). Following the intervention, the experimental group achieved a significantly higher post-test mean score (M = 41.57, SD = 3.26) compared to the control group (M = 33.32, SD = 5.22), with a statistically significant difference, $t(58) = -6.50$, $p < .001$, indicating a large effect size ($\eta^2 = .48$). Within-group analysis further showed substantial improvement in the experimental group, $t(29) = -12.77$, $p < .001$, compared to the control group, $t(29) = -6.03$, $p < .001$. Qualitative findings revealed that mind mapping enhanced students' organization of ideas, creativity, collaboration, and critical thinking in solving contextualized mathematical problems. **Novelty:** Despite growing evidence on the benefits of mind mapping in mathematics education, limited studies have examined its effectiveness in improving students' performance in contextualized PISA-type mathematics tasks among Filipino junior high school learners. This study addresses this gap by providing contextualized empirical evidence that mind mapping can improve students' mathematical reasoning, organization of ideas, and higher-order thinking skills through visual and collaborative learning strategies.

Keywords: Mind Mapping; Mathematics Achievement; Contextualized Mathematics Problems; Mixed-Methods Research

1 Introduction

As modern society becomes increasingly complex, there is a growing demand for people who can use mathematics in practice and make informed decisions based on available data. As a result, mathematics education has led to a focus on understanding and applying mathematics over rote learning of procedural knowledge. For example, the Programme for International Student Assessment (PISA) measures mathematics literacy as how well students can apply their mathematical knowledge to solve real-world and non-routine problems⁽¹⁾. This study defines mathematical literacy as the ability to solve and apply mathematics in real-life situations⁽²⁾. Despite this emphasis, many learners are still experiencing difficulties with the contextualized higher-order mathematical tasks, which involve problem solving.

Rahmawati et al.⁽²⁾ reported that students often struggle with understanding mathematical problems including determining key aspects of the problem, choosing appropriate methods to solve problems in new contexts. The low performance of students in international large-scale assessments, particularly in mathematical reasoning and contextualized problem solving, suggests a similar challenge for the Philippines. These concerns suggest the importance of instructional strategies that help students organize their understanding, connect ideas, and apply mathematical concepts.

Mind mapping as an instructional strategy has been gaining a lot of popularity lately. Mind maps are techniques that fall into the category of visual learning strategies whereby learners can hierarchically organize ideas, create conceptual connections, and build coherent cognitive structures. Constructivist learning theory — which describes how learners develop knowledge by combining new information with already existing knowledge — may explain why it is effective. Similarly, dual coding theory posits that verbal, and visual representations together facilitate understanding and memory. Thus, mind mapping may help promote deep comprehension and mathematical reasoning through visual organization and linking of concepts.

Research over the last few years indicates positive effects of mind mapping on students' engagement, conceptual understanding and academic performance in both mathematics and STEM education. In their study, Elhilal and Belghiti⁽³⁾ discovered that concept mapping enhances mathematical understanding of students. Likewise, mind mapping has been shown to facilitate learning by activating prior knowledge and scaffolding comprehension⁽⁴⁾. In relation to PISA-type mathematics problems, Darsan et al.⁽⁵⁾ demonstrated that mind mapping as a visual tool that can simplify mathematical concepts and increase students' capacity to analyze information whereas Nasution et al.⁽⁶⁾ reported improvements in mathematical communication and learning interest. Systematic reviews by Kefalis et al.⁽⁷⁾ and Shi et al.⁽⁸⁾ further showed that mind mapping enhances cognitive learning outcomes and higher-order thinking skills. Collectively, these studies suggest that mind mapping supports both cognitive processing and learner engagement. However, most previous studies focused primarily on general mathematics achievement, conceptual understanding, or classroom engagement rather than students' performance in contextualized PISA-type mathematical tasks.

Despite growing evidence supporting mind mapping as an instructional strategy, limited research has examined its effectiveness in improving students' achievement in PISA-type mathematics tasks, particularly among Filipino junior high school learners. Existing studies have largely concentrated on conventional mathematics performance without explicitly examining non-routine, context-based assessments that require mathematical literacy, reasoning, and real-world application. Furthermore, few mixed-methods studies have explored not only the quantitative effects of mind mapping on achievement but also students' learning experiences while using the strategy.

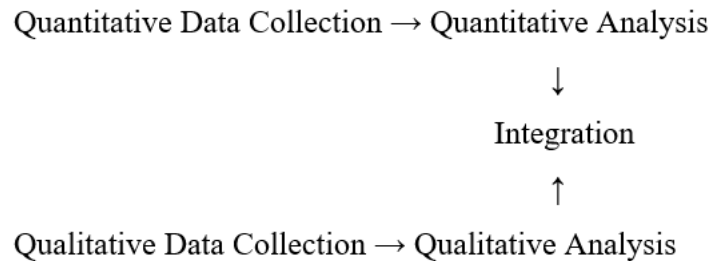
Therefore, this study aimed to examine the effectiveness of integrating the mind-mapping technique in strengthening students' competency in Programme for International Student Assessment (PISA)-type mathematics tasks. Specifically, the study sought to answer the following research questions:

1. What is the level of mathematics achievement in the pre-test and post-test of students exposed to mind-mapping instruction and those receiving conventional instruction in PISA-type mathematics tasks?
2. Is there a significant difference in the pre-test achievement scores between students exposed to mind-mapping instruction and those receiving conventional instruction?
3. Is there a significant difference between the pre-test and post-test achievement scores of students exposed to mind-mapping instruction and those receiving conventional instruction?
4. Is there a significant difference in the post-test achievement scores between students exposed to mind-mapping instruction and those receiving conventional instruction?

2 Methodology

A convergent parallel mixed-methods design was used in this study to measure the effect of mind-mapping techniques on students' competency in solving PISA-type mathematics tasks. This involved the simultaneous collection of quantitative and

qualitative data, with separate analyses and integration during interpretation to provide a more holistic view of the research⁽⁹⁾. The quantitative part investigated students' mathematics achievement before and after the intervention, while the qualitative component explored learners' experiences using mind mapping. Findings were integrated by comparing and triangulating quantitative results and qualitative themes to explain how students' experiences corresponded to observed improvements in mathematics achievement. This process provided a more holistic understanding of mind mapping as an effective tool for solving real-life mathematical problems. A visual diagram of the mixed-methods process was also included to illustrate the research procedure.



2.1 Research Participants and Sampling

Participants were sixty (60) Grade 7 students from a public secondary school in Iloilo Province, Philippines, during School Year 2024–2025. Cluster random sampling was employed to select the participants. Two intact Grade 7 classes with comparable academic schedules and learning competencies were identified by the school administration. The classes were then randomly assigned through a simple draw-lots procedure to either the experimental group ($n = 30$) or the control group ($n = 30$).

Prior to the intervention, baseline equivalence between groups was established through pre-test results, which indicated no statistically significant difference in mathematics achievement between the experimental and control groups. This comparability strengthened the internal validity of the study by ensuring that both groups had similar levels of competency before the intervention.

To minimize contamination threats between groups, the two classes were scheduled at different instructional periods and students were instructed not to share intervention materials or activities throughout the study. Both groups were also taught by the same instructor using identical learning competencies, instructional materials, assessment tasks, and time allotments, with the instructional strategy serving as the only differing variable.

As the primary independent variable, both groups were controlled in terms of learning competencies, instructional time, and assessment tasks to establish baseline comparability for internal validity purposes. The design allowed the observed differences in outcomes to be attributed primarily to the intervention rather than to extraneous variables. However, the relatively small sample size and the use of participants from only one public secondary school may limit the generalizability of the findings to broader educational contexts.

2.2 Research Instrument

The primary dataset consisted of a PISA-type mathematics assessment designed by the researchers with associated qualitative student responses regarding their learning experiences over the course of the intervention.

The assessment tool was constructed using the topics of integers and polynomials under the Grade 7 Mathematics Most Essential Learning Competencies (MELCs) based on the MATATAG curriculum. The process of developing the assessment proceeded through (1) identifying targeted competencies, (2) writing contextualized real-world problem scenarios that were aligned with PISA frameworks, then (3) composing assessment items and (4) preparing an analytic scoring rubric to ensure that the evaluation of student solutions was standardized. The final instrument included a total of 27 items across eight real-world mathematical contexts, with a maximum possible score of 65 points.

To ensure content validity, the instrument was assessed by three mathematics education experts: one professor of mathematics education, one master teacher in senior high school, and a curriculum specialist with experience in assessment development. The validators reviewed the instrument regarding the relevance of content, alignment to learning competencies, clarity of language, appropriateness of contextualized tasks, and suitability for Grade 7 learners. Changes based on their recommendations were made to clarify items and ensure alignment.

Pilot testing was conducted among Grade 7 students of another public secondary school who were not part of the actual study to avoid bias. The pilot implementation revealed excellent internal consistency (Cronbach's alpha coefficient = 0.91), supporting the reliability of the instrument.

2.3 Intervention Procedure

The intervention lasted for 6 weeks, which was a sufficient period of exposure to the instructional strategy and aligned with the school's curricular pacing and available resources. Students in the experimental group underwent an orientation before the intervention on what mind mapping is and how to identify central concepts, organize related ideas into branches and visually represent relationships between mathematical concepts. Mind map samples were modeled and practice activities followed to help students understand the strategy before its implementation in the classroom.

To control extraneous variables and maintain treatment fidelity, both groups worked with the same lesson plans, learning competencies, instructional materials, assessment tasks, and time allotment. The instructional strategy was the only variable that differed between groups, and all lessons were implemented by the same teacher.

The experimental group was instructed using the mind-mapping technique. Students created mathematical concept maps that organized core concepts, formulas, relationships, and solution processes into interconnected visual structures. Classroom activities included identifying key information from contextualized mathematical problems, constructing individual and collaborative mind maps, presenting relationships among concepts, and using mind maps to plan solutions to PISA-type mathematical tasks. For example, students organized problem information into branches such as known values, mathematical operations, relationships among variables, and possible solution strategies before attempting to solve the tasks. Collaborative activities also allowed students to discuss and refine their visual representations with peers.

In contrast, the control group received conventional instruction through teacher-centered discussion, guided practice, and routine problem-solving activities without the use of mind mapping techniques.

Treatment fidelity was monitored throughout the intervention through consistent implementation of standardized lesson plans, regular classroom observations, and the use of instructional checklists to ensure adherence to the intended procedures for both groups. The same instructor handled both groups to minimize variations in teaching style and instructional delivery. Although the use of a single teacher helped control teacher-related variability, the possibility that teacher effects influenced the findings cannot be entirely eliminated and is acknowledged as a potential limitation of the study.

Thus, this structured comparison functioned as a form of internal control, allowing observed differences in performance to be more confidently attributed to the intervention.

2.4 Data Collection Procedure

Permission to conduct the study was sought and obtained from the relevant school authorities prior to data collection. Informed consent was likewise secured from the participating students and their parents or guardians before the implementation of the study.

Data collection was organized into three phases: pre-experimental, experimental, and post-experimental stages. During the pre-experimental stage, both the experimental and control groups completed a pre-test consisting of the researcher-developed PISA-type mathematics assessment to determine their baseline competency in solving contextualized mathematical problems.

The intervention was implemented over a six-week period during the experimental stage. Throughout the intervention, both groups studied the same mathematics topics and completed similar learning activities and assessment tasks to maintain equivalent instructional conditions. The experimental group received instruction using mind-mapping techniques, while the control group received conventional instruction.

During the post-experimental stage, both groups completed the same researcher-developed PISA-type mathematics assessment as a post-test to determine changes in mathematics achievement after the intervention. The use of the same instrument allowed for direct comparison of students' performance before and after the instructional treatment. To minimize possible testing effects resulting from repeated exposure to similar assessment tasks, a sufficient time interval was observed between the pre-test and post-test administrations, and students were not provided with copies of the test items or answer keys after the pre-test. In addition, the six-week intervention period and the integration of varied classroom activities helped reduce the likelihood of students recalling specific responses from the initial assessment.

2.5 Statistical Analysis

The Statistical Package for the Social Sciences (SPSS) was used to analyze quantitative data. For descriptive data analysis, mean and standard deviation were used to determine students' mathematics achievement.

Inferential statistics were chosen based on the characteristics of data and study design. An independent samples *t*-test was performed to check the differences between experimental and control groups while a paired sample *t*-test was conducted to compare within-group differences in pretest–posttest scores. Testing assumptions were performed before conducting the parametric tests. The Shapiro–Wilk test and visual examination of normality plots were used to assess the normality of score distributions, while Levene’s test was used to investigate homogeneity of variance. Results showed that parametric testing assumptions were adequately satisfied.

All statistical analyses were performed at the 0.05 level of significance, which is a widely adopted threshold in educational research that balances the risks of Type I and Type II errors. All statistical values for significance tests (*t*-values, degrees of freedom, *p*-values, confidence intervals, and effect sizes) were reported uniformly across the study in order to provide consistency and clarity in reporting. Confidence intervals were also reported to provide further information about the precision of estimated mean differences.

In the qualitative component, thematic analysis was conducted according to systematic processes which included data familiarization, initial coding, theme generation, theme review, theme definition, and interpretation. The responses of students were analyzed for overarching patterns and meaning associated with their experiences using mind mapping. To enhance qualitative rigor and credibility, peer debriefing was undertaken with a research colleague experienced in conducting thematic analysis to examine the coding framework and content themes. Codes and themes were discussed, refined, and consolidated to agreement. This process strengthened the rigor, credibility, and transparency of the qualitative results.

2.6 Ethical Considerations

Ethical principles were strictly observed throughout the study. Participation in the research was voluntary, and informed consent was obtained from both students and their parents or guardians. Ethical clearance was obtained from the appropriate institutional ethics review board prior to the conduct of the study. To ensure confidentiality and protect participants’ identities, pseudonyms were assigned to student responses during data analysis and reporting. All collected data were used solely for research purposes and were treated with strict confidentiality.

3 Results and Discussion

3.1 Quantitative Results

3.1.1. Mathematics Achievement of Students Before and After the Intervention

Students’ mathematics achievement in PISA-type mathematics assessments was examined by comparing the pre-test and post-test performance of learners exposed to mind-mapping instruction and those receiving conventional instruction. Descriptive statistics were used to determine the achievement levels of both groups prior to and following the instructional intervention. Before the intervention, both the experimental and control groups demonstrated low levels of mathematics achievement in solving PISA-type mathematical problems. The experimental group obtained a mean score of ($M = 24.48$, $SD = 6.72$), while the control group obtained a mean score of ($M = 23.44$, $SD = 7.44$). These results suggest that students initially had a limited ability to analyze contextualized mathematical problems and apply mathematical concepts to real-life situations.

The low baseline performance in PISA-type tasks is consistent with previous research showing that students struggle to solve non-routine, context-based mathematics tasks that involve interpretation and reasoning rather than procedural computation⁽¹⁾. While this gap has predominantly been attributed to a poor understanding of the concepts, our research suggests that they may also struggle with organizing information when solving complex problems.

Following the six-week instructional period, improvements in mathematics achievement were observed in both groups. The experimental group obtained a post-test mean score of ($M = 41.57$, $SD = 3.26$), which corresponds to a high level of achievement, while the control group obtained a mean score of ($M = 33.32$, $SD = 5.22$), interpreted as an average level of achievement. These improvements indicate that students developed a better understanding of mathematical concepts and were able to organize and apply information more effectively when solving contextualized mathematical problems.

These findings are supported by Hazaymeh and Alomery⁽¹⁰⁾, who found that mind mapping facilitates critical thinking by enabling learners to analyze and connect concepts. According to Babadoğan⁽¹¹⁾, mind mapping encourages structured learning among students as it assists them in building and organizing meaningful knowledge. Munir et al.⁽¹²⁾ reported that mind mapping improved understanding of instructional content by stimulating students to participate in the learning process. In addition, Jiang et al.⁽¹³⁾ also found that well-structured and interactive learning environments promote students to become more engaged and perform better. According to Besas et al.⁽¹⁴⁾, this approach also results in improved academic outcomes because learner-centered strategies foster self-directed and reflective learning. Yarmi et al.⁽¹⁵⁾ also explained that mind mapping

is a strategy to improve learning performance by getting students to connect and arrange ideas. However, these studies consistently identify benefits for engagement, cognition, and general academic outcomes, but not specifically in the context of assessment tasks. In contrast, Wienecke et al.⁽¹⁶⁾ highlighted that the use of structured strategies leads to a greater ability among students to solve real-world mathematical problems, which are more characteristic of PISA-type tests. In contrast to previous studies focusing on general achievement or cognitive gains, the current results showed that mind mapping enhances students' performance on PISA-type mathematics tasks, which necessarily involve interpretation, reasoning, and the real-world application of knowledge. Table 1 presents the data.

Table 1. Pre-Test and Post-Test Mathematics Achievement of Students in PISA-type Mathematics Assessments

Group	Test	Mean	SD	Interpretation
Experimental (Mind Mapping)	Pre-test	24.48	6.72	Low
Experimental (Mind Mapping)	Post-test	41.57	3.26	High
Control (Conventional Instruction)	Pre-test	23.44	7.44	Low
Control (Conventional Instruction)	Post-test	33.32	5.22	Average

Note: Interpretation scale — Very Low (0–13), Low (13.01–26), Average (26.01–39), High (39.01–52), Very High (52.01–65).

3.1.2. Difference in Pre-Test Achievement between Groups

The difference in pre-test achievement scores between students exposed to mind-mapping instruction and those receiving conventional instruction was examined to determine whether the two groups had comparable levels of mathematical competency prior to the instructional intervention. An independent samples t-test was conducted to assess whether a significant difference existed between the two groups at the baseline stage. The results revealed no statistically significant difference between the experimental group ($M = 24.48$, $SD = 6.72$) and the control group ($M = 23.44$, $SD = 7.44$), $t(58) = -0.51$, $p = .616$. The mean difference between the two groups was $MD = -1.04$, with a 95% confidence interval ranging from -5.17 to 3.10. The effect size was small ($\eta^2 = .01$).

These findings indicate that both groups had comparable levels of mathematical proficiency in PISA-type assessments prior to the intervention. Establishing baseline equivalence is essential in experimental research, as it strengthens the internal validity of the study by ensuring that any observed differences in post-test performance can be attributed to the instructional intervention rather than pre-existing differences between groups. Creswell and Creswell⁽⁹⁾ emphasized that establishing equivalence between groups is a fundamental requirement in mixed-methods and experimental designs to ensure valid comparisons of outcomes. However, while many studies on mind mapping emphasize post-intervention gains in learning outcomes, they often provide limited discussion on baseline comparability between groups. Kefalis et al.⁽⁷⁾ highlighted that most studies focus on effectiveness after the intervention rather than methodological rigor at the pre-intervention stage. This study addresses this limitation by explicitly demonstrating statistical equivalence between groups before the intervention, thereby strengthening the validity and credibility of the subsequent findings. Table 2 presents the data.

Table 2. Difference in Pre-Test Achievement Scores between Students Exposed to Mind-Mapping Instruction and Conventional Instruction

Group	Mean	SD	MD	95% CI	df	t	p	η^2
Experimental (Mind Mapping)	24.48	6.72	-1.04	-5.17 to 3.10	58	-0.51	.616	.01
Control (Conventional Instruction)	23.44	7.44						

3.1.3. Difference between Pre-Test and Post-Test Achievement Scores

The difference between the pre-test and post-test achievement scores of students exposed to mind-mapping instruction and those receiving conventional instruction was examined to determine whether the instructional intervention significantly improved students' performance in PISA-type mathematics assessments. A paired samples t-test was conducted to assess changes in students' mathematics achievement before and after the instructional intervention.

The results revealed a statistically significant difference between the pre-test and post-test scores of students exposed to the mind-mapping technique. The experimental group obtained a pre-test mean score of ($M = 24.48$, $SD = 6.72$) and a post-test mean score of ($M = 41.57$, $SD = 3.26$), $t(29) = -12.77$, $p < .001$. The mean difference was $MD = -17.09$, with a 95% confidence interval ranging from -19.86 to -14.31, indicating a large effect size ($\eta^2 = .78$). This result suggests a substantial improvement in students' mathematics achievement following exposure to the mind-mapping instructional strategy.

Similarly, the control group also demonstrated a statistically significant difference between pre-test and post-test scores. Students exposed to conventional instruction obtained a pre-test mean score of ($M = 23.44$, $SD = 7.44$) and a post-test mean score of ($M = 33.32$, $SD = 5.22$), $t(29) = -6.03$, $p < .001$. The mean difference was $MD = -9.88$, with a 95% confidence interval ranging from -13.26 to -6.50, indicating a large effect size ($\eta^2 = .44$).

These improvements can be explained by the cognitive processes supported through mind mapping. Hazaymeh and Alomery⁽¹⁰⁾ stated that visual mind mapping helps learners develop better critical thinking as it allows them to define connections among concepts by organizing the data logically. According to Babadoğan⁽¹¹⁾, mind mapping facilitates systematic learning among students, who can organize and learn in a structured way. Munir et al.⁽¹²⁾ reported that mind-mapping enhances learning in terms of active engagement and understanding subject matter at a deeper level. In line with these, a study by Elhilal and Belghiti⁽³⁾ demonstrated that conceptual mapping enhances students' mathematical achievement by identifying relations among concepts in which links predict sustained learning gains. Shi et al.⁽⁸⁾ provided additional support for the potential of mind mapping to promote higher-order thinking processes, which ultimately relate to better academic performance. Table 3 presents the data.

Table 3. Difference between Pre-Test and Post-Test Achievement Scores of Students

Group	Test	Mean	SD	MD	95% CI	df	t	p	η^2
Experimental (Mind Mapping)	Pre-test	24.48	6.72	-17.09	-19.86 to -14.31	29	-12.77	<.001	.78
	Post-test	41.57	3.26						
Control (Conventional Instruction)	Pre-test	23.44	7.44	-9.88	-13.26 to -6.50	29	-6.03	<.001	.44
	Post-test	33.32	5.22						

3.1.4. Difference in Post-Test Achievement between Groups

The difference in post-test achievement scores between students exposed to mind-mapping instruction and those receiving conventional instruction was examined to determine whether the instructional intervention produced different learning outcomes in Programme for International Student Assessment-type mathematics assessments. An independent samples t-test was conducted to assess whether the post-test scores of the two groups differed significantly after the instructional intervention.

The results revealed a statistically significant difference between the experimental and control groups. Students exposed to mind-mapping instruction obtained a post-test mean score of ($M = 41.57$, $SD = 3.26$), whereas students who received conventional instruction obtained a mean score of ($M = 33.32$, $SD = 5.22$). The analysis indicated $t(58) = -6.50$, $p < .001$, demonstrating that the difference between the two groups was statistically significant. The magnitude of the mean difference was $MD = -8.25$, with a 95% confidence interval ranging from -10.80 to -5.69, indicating a large effect size ($\eta^2 = .48$).

These results corroborate the results of Jiang et al.⁽¹³⁾ who reported that structured and technology-enhanced learning environments lead to better student engagement and academic performance. Besas et al.⁽¹⁴⁾ also reported that learner-centered and self-directed approaches promote active and reflective learning processes, which in turn improve students' achievement. Yarmi et al.⁽¹⁵⁾ additionally, showed that mind mapping enhances student learning performance through better organization and integration of ideas. Wienecke et al.⁽¹⁶⁾ also added that structured strategies provide additional reasoning, and organization supports that positively influence students' performance on authentic mathematical tasks. However, such studies consistently report positive benefits on both engagement, organization and overall academic performance but either focus mainly on higher order learning outcomes or more technology supported environments rather than performance in standardized context based assessment, particularly for novel mathematical assessment. On the other hand, this study shows that mind mapping significantly increases the performance specifically on PISA-type mathematics tasks. This distinction forms one of the main contributions of the study. The current findings provide direct evidence that mind mapping improves students' ability to solve specific types non-routine, context-based mathematical problems, more so than previous studies focusing on engagement or general achievement. This adds to the existing literature by connecting instructional strategy with not only enhanced performance but also fostering competencies aligned with mathematical literacy. Table 4 shows the data.

Table 4. Difference in Post-Test Achievement Scores between Students Exposed to Mind-Mapping Instruction and Conventional Instruction

Group	Mean	SD	MD	95% CI	df	t	p	η^2
Experimental (Mind Mapping)	41.57	3.26	-8.25	-10.80 to -5.69	58	-6.50	<.001	.48
Control (Conventional Instruction)	33.32	5.22						

3.2 Qualitative Results: Learners' Experiences in Using Mind Mapping in PISA-type Mathematics Assessments

3.2.1. Theme 1: Enhanced Understanding and Organization of Ideas

One of the most significant themes to emerge from the students' responses was that mind mapping improved their ability to process and structure complex information. Mind mapping is recognized as a cognitive tool that helps learners to structure and understand difficult subjects (especially within mathematics). According to Hazaymeh and Alomery⁽¹⁰⁾, mind mapping helps learners analyze relationships between concepts and structure information in a logical way.

This is exemplified by Narra's statement:

"Namian ako mag gamit sang mind map kay mas napadali ang pag plan kag paganswer sang mga activities kay mahapos matandaan kag maintindihan ang mga impormasyon" [**I liked using mind maps because they make planning and answering activities easier since the information is easy to understand and remember**].

The visual nature of mind maps enabled learners to break down complex problems into manageable parts, facilitating the identification of main topics and related subtopics. Mahogany supports this, saying:

"Naka bulig gid sa pag-organize sang akon mga ideas... makita ko dayon ang main topic kag ang mga related subtopics" [**It helped me organize my ideas... I can immediately see the main topic and related subtopics, making the flow of my answer much clearer**].

This process not only promoted a logical flow of ideas but also aided planning and structuring responses coherently, as Acacia noted:

"Nagabulig ini nga mas klaro ko makita ang koneksyon sang mga ideya... may sentro kag may mga branches nga naga-represent sang related nga mga concepts" [**It helped me see the connections between ideas clearly... it has a central idea with branches representing related concepts**].

These findings suggest that mind mapping helps organize ideas into structured representations in the minds of learners. Munir et al.⁽¹²⁾ found that mind mapping has a role in enhancing understanding because active engagement can increase the depth of processing during learning. Nevertheless, many earlier studies highlight how mind mapping is regarded as having a positive impact on both overall understanding and organisation but these benefits were discussed in laboratory or theoretical settings. Conversely, the current results provide direct learner-oriented evidence of the strategies used for organizing information when solving PISA-style mathematical problems. This is a major finding of the study since it shows that mind mapping has been found to help support comprehension and works towards structured thinking in context-driven mathematical tasks — an aspect that is critical to achieving mathematical literacy.

3.2.2. Theme 2: Creativity and Personal Expression

Another significant theme that came out of the data is how creativity and personal expression mattered in the learning process through mind mapping. Students liked the ability to draw shapes, colors, and patterns in their mind maps as it made learning more engaging and enjoyable. Elhilal and Belghiti⁽³⁾, showed that the use of visual and structured mapping methods provides learners with tools to creatively represent ideas, which is an advantage when improving conceptual understanding.

As Mahogany shared:

"...Naga drawing ako sang mga shapes kag gina connect ko ang mga impormasyon nga ginahatag... naga learn gid ko" [**...I draw shapes and connect the given information..., I really learned**].

This creative freedom allowed students to personalize their work, making abstract mathematical concepts more concrete and relatable. Mapple expressed:

“Nanamian gid ko mag-ubra mind map kay napakita gid ang akon drawing skills kag ma express ko gid akon mga ideas...” [I really like creating mind maps because I can showcase my drawing skills and express my ideas].

While Molave added:

“I can create different patterns while crafting a mind map.”

The use of visual elements not only enhanced the aesthetic appeal of the mind maps but also served as mnemonic aids that supported recall and understanding. Yakal noted:

“Gaenjoy ako ubra sang mind-map kay na designan ko ang akon ubra” [I enjoyed crafting mind maps because I got to design my work].

This indicates that creativity incorporated into mind mapping has a positive impact on making sense of things through engagement with deliberate practice. Munir et al.⁽¹²⁾ discovered that mind mapping promotes engagement and deeper comprehension through active involvement in learning activities. Nonetheless, while previous research highlights the importance of creativity in improving motivation and comprehension they treat creative expression as a generic enhancer of learning rather than considering it an essential functional aspect to problem solving. Babadoğan⁽¹¹⁾ noted that mind mapping is mostly considered as an assistance for learning rather than a way to structure or even codify problem-solving processes. On the other hand, results of this study indicate that creative expression in mind mapping more directly supports students in developing organized and structured solutions to tasks similar to PISA-type mathematics problems. Wienecke et al.⁽¹⁶⁾ emphasized that structured representation strategies support students in planning how to organize the information and reasoning processes needed for real-world mathematical problems. This means that creativity is not only motivational but also cognitively functional, since it assists learners in structuring and communicating mathematical ideas during context-based problem-solving scenarios.

3.2.3. Theme 3: Collaboration and Social Learning

Collaboration and social learning emerged as a significant theme in students’ experiences with mind mapping. Nasution et al.⁽⁶⁾ reported that mind-mapping activities enhance students’ communication skills and engagement by encouraging interactive and cooperative learning. Many students shared that working together to create mind maps facilitated idea sharing, clarified misunderstandings, and increased their confidence in solving mathematical problems.

Pine shared,

“Nakabalo gid ko mag-cooperate sa group ko in organizing sang mga ideas... buligay gid kami sang mga group mates ko mag solve sang mga problem” [I learned to cooperate with my group in organizing ideas... we help each other solve problems].

This collaborative process also alleviated feelings of shyness and anxiety, especially when presenting their work. Balete noted:

“Nanamian ko ya mag reporting sang amon nga ubra upod mga group mates ko kay nagabuligay kami daw wala ko nahadlok mag report sa tunga sa mga classmates ko” [I liked reporting our group work because we help each other, and I am not afraid to present in front of the class].

Such social interaction not only enhanced communication skills but also fostered a supportive learning environment where students felt comfortable expressing their thoughts.

This theme shows how mind mapping promoted cooperative learning and social engagement among students. Group work encouraged the sharing of ideas, reduced anxiety, and strengthened communication abilities. Ipil-ipil remarked:

“Gamit ang mind-map sa ulobrahon sang group naibanan ang akon huya-huya sa mga classmates ko” [Using mind maps in group work lessened my shyness toward my classmates],

While Talisay expressed:

“Excited ko kay ginabuligan ako sang grupo ko... wala ko nabudlayan mag-answer” [I am excited because my teammates help me... it’s not difficult for me to answer].

These responses indicate that collaboration fostered a space where learners were encouraged to participate and share ideas. Nevertheless, previous research considers collaboration as a positive aspect of participatory presence within the classroom where interaction is discussed generally rather than within structured problem-solving contexts.

In contrast, the current study demonstrates that collaborative mind mapping not only facilitates interaction but also joint problem-solving processes through collaboratively organizing, analyzing, and interpreting information in PISA-type mathematical tasks. Kefalis et al.⁽⁷⁾ noted that structured collaborative learning (with visual tools) resulted in better shared understanding, which relates to the observed improvement in shared understanding and reflective thinking. This emphasizes a major contribution of this study, since the finding shows that collaborative mind mapping not only acts as social support but also acts as a cognitive tool that enhances group-based reasoning and problem solving in context-based mathematics learning.

3.2.4. Theme 4: Development of Critical Thinking Skills

The development of critical thinking skills emerged as an important theme in students' experiences with mind mapping. Hazaymeh and Alomery⁽¹⁰⁾ reported that visual mind mapping strategies enhance learners' critical thinking by enabling them to analyze relationships among concepts and organize information systematically. Students reported that constructing mind maps encouraged them to examine relationships between different pieces of information and think more carefully when solving PISA-type mathematical problems. One student explained:

**“Dapat gid ya nga palibugan kun ano ang relationship sang ginahatag nga mga information sa mga questions.”
(You really need to think carefully about the relationship between the given information and the questions.)**

Another participant highlighted the importance of organizing and understanding information in order to arrive at the correct solution:

“To have a correct answer, you need to read and understand critically, organize information, and find relationships.”

Similarly, another student noted that mind mapping helped them identify supporting details and connections among ideas:

“By branching out from a central idea, you can map out supporting details, causes, effects, and relationships.”

Another learner explained that the process of creating mind maps required deeper thinking:

**“Kun mag gamit mind-map dapat guid palibugan.”
(When using mind maps, you really need to think carefully.)**

Finally, one student emphasized how the activity encouraged thoughtful reasoning:

**“Daw gina encourage gid ko nga magpanumdom maayo.”
(I feel encouraged to think more carefully.)**

These findings imply that mind mapping encourages higher-level analytical thinking, where students have to organize ideas and make connections between different information while solving mathematical problems. Nevertheless, supporting critical thinking by mind mapping has not been studied in the way that it focused on developing cognitive skills across learning contexts without emphasizing task-oriented problem-solving design.

In contrast, the findings in this study show that mind mapping encouraged critical thinking among students in real-life PISA-type mathematical problems involving interpreting information, identifying relationships and applying appropriate reasoning strategies. According to Shi et al.⁽⁸⁾ mind mapping promotes higher-order thinking processes necessary for solving complex and non-routine tasks. This adds a major value to the study by indicating that mind mapping not only enhances critical thinking in general but also reasoning and problem solving specific to context-based tasks- an integral aspect of mathematical literacy.

3.2.5. Theme 5: Initial Challenges and Adaptation

Initial challenges and adaptation emerged as a theme in students' experiences with mind mapping. Babadoğan⁽¹¹⁾ noted that learners may initially encounter difficulty when using mind mapping, particularly when they are unfamiliar with organizing information into structured visual formats.

Several students described the difficulties they experienced during the early stages of the activity. One learner shared:

“At first, it was hard because I didn’t understand how to make a mind map, but with the help of my classmates, I learned to make one on my own and really like using it.”

Another student expressed a similar experience:

“Sa una nabudlayan gid ko... pero mahapos man lang gali kapin pa nagabuligay kami.”

(At first I really had difficulty, but it turned out to be easy especially when we helped each other.)

Another participant noted that drawing was not their strength but still attempted to complete the task:

“Bisan kalain ako mag drawing pero gina try ko man gyapon mag ubra sang mind-map.”

(Even though I am not good at drawing, I still try to make a mind map.)

These responses indicate that students struggled with mind mapping at first but adapted to the technique through practice, peer modeling, and effortful engagement. Nevertheless, previous work only acknowledges that learners are likely to struggle with new instructional approaches in the first few instances of exposure but typically provides little elaboration on how students overcome these difficulties over time. In contrast, the present findings indicate that the students not only adjusted to using mind mapping but also became confident and autonomous in employing this strategy to address PISA-type mathematical problems. Yarmi et al.⁽¹⁵⁾ stressed that continued use of mind mapping enhances students' learning performance and familiarity with the strategy, confirming a shift from difficulty to competence. This is one of the main contributions made in this paper; it highlights that mind mapping as a new method may be challenging at first but with collaborative learning and sustained practice, ultimately supports positive learning outcomes.

3.3 Integration of Quantitative and Qualitative Findings

The quantitative and qualitative findings were integrated to develop a more comprehensive understanding of how mind mapping influenced students' competency in solving PISA-type mathematics problems. The quantitative results demonstrated that both groups had low mathematics achievement according to the pre-test. Qualitatively, students also reported that they had trouble organizing and interpreting information when contextualized mathematical problems were presented to them initially, which corroborated the quantitative findings. These learners described feeling that their ideas did not connect easily, particularly in determining how the information and questions related to each other. These experiences indicate that students had limited ways to organize their mathematical thinking before the intervention.

After the instructional intervention, quantitative outcomes indicated an increase in post-test achievement scores among students. Qualitative findings converged with the quantitative results by showing that students perceived mind mapping as an effective strategy for organizing and understanding mathematical concepts. Learners revealed that mind maps structured their ideas visually by enabling them to understand the relationships among mathematical concepts and also helped them develop more systematic solutions. Such improved organization of ideas likely explains the observed improvement in students' mathematical performance.

The convergence of quantitative and qualitative findings was further evident in the higher post-test performance of students exposed to mind mapping. Qualitative findings further supported this result by showing that learners were more inclined to critically analyze problems. Students claimed that building the mind maps helped them link pieces of information and assess how these ideas were related in order to solve PISA-type problems. These processes reflect higher-level thinking skills essential for problem solving.

Moreover, the substantial enhancement in achievement scores for the experimental group may also be related to creative and collaborative mind-mapping. Learners explained that using drawings, colors, or patterns to represent their ideas made learning more fun because they could represent ideas creatively. Moreover, learners pointed out that collaborative mind-mapping practices provided opportunities for them to exchange ideas with their peers and offered assistance from other group members when addressing problems. These interactive learning experiences may have contributed to greater engagement, improved understanding of mathematical concepts, and enhanced performance in contextualized problem-solving tasks. Table 5 shows the joint display of quantitative and qualitative findings.

Table 5. Joint Display of Quantitative and Qualitative Findings

Quantitative Findings	Qualitative Findings	Integrated Interpretation
Increased post-test scores	Students reported improved organization of ideas	Mind mapping enhanced structured mathematical thinking
Higher post-test performance in the experimental group	Students described deeper analysis of problems	Mind mapping supported critical thinking and reasoning
Significant improvement after intervention	Students reported positive collaborative learning experiences	Collaborative learning increased engagement and understanding

4 Conclusion

This study employed a convergent parallel mixed-methods design to examine the effects of mind-mapping techniques on students' performance in Programme for International Student Assessment (PISA)-type mathematics tasks. The findings indicate that students initially struggled with solving contextualized mathematical problems; however, after the instructional intervention, they demonstrated improved understanding and problem-solving capability.

The qualitative findings also indicated that mind mapping aided students in organizing ideas, connecting concepts, and thinking critically when solving the contextualized mathematical tasks. Students also expressed increased creativity, collaboration, and confidence during the learning process; all of which reflected the affective dimension of learning through mind mapping.

One of the main contributions of this study is that it shows how mind mapping helps learners develop competencies in solving non-routine and contextualized problems through appropriate problem-solving approaches. It also builds on earlier studies by showing that mind mapping is not only a pedagogical tool for smooth learning, but it can also help develop mathematical literacy skills such as reasoning, interpretation, and real-world application of knowledge among Filipino junior high school students.

However, despite these contributions, the study had a few limitations. The focus of the research was on a single public secondary school in Iloilo Province with a limited number of participants, which may limit the transferability of the findings across different educational settings and student populations. Also, the intervention lasted for six weeks “which may have been too short to evaluate the long-term impact on mathematical performance and reasoning skills.

Future research can investigate the sustained outcomes of mind mapping in various grade levels, disciplines, and teaching contexts. Future studies may also investigate the incorporation of digital mind-mapping tools and emergent educational technologies into context-based mathematics teaching practices. Moreover, it recommended the use of larger and more heterogeneous samples to increase results generalizability.

The findings of this study have important implications for mathematics instruction, particularly in developing students' mathematical literacy and contextualized problem-solving skills. Mathematics teachers may integrate mind-mapping techniques into classroom instruction to help students organize concepts, connect ideas, and solve complex mathematical problems more effectively. In addition, curriculum developers may incorporate mind-mapping strategies into instructional materials and assessment practices to support the development of higher-order thinking skills among learners.

5 Disclosure

Funding: No funding was received for this study.

Data Sharing Statement: The data supporting the findings and conclusions of this study are available from the corresponding author upon reasonable request.

Ethical Statement: The authors confirmed that all participants voluntarily agreed to participate in this study. Written informed consent was obtained from the participants and their parents or guardians prior to data collection. Personal identities of the participants were kept anonymous, and all information gathered was treated with strict confidentiality.

Declaration of Interest: The authors declare no conflict of interest.

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