

The Effect of Comic-Based Realistic Mathematics Approach (RMA) on The Critical Thinking Skills of Grade 9 Students

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Abstract. This study investigated the effect of the Comic-Based Realistic Mathematics Approach (RMA) on the critical thinking skills of Grade 9 students at Wenceslao Trinidad Memorial National High School. Specifically, it examined the level of implementation of RMA in terms of the use of comic-based scenarios, application of real-life problem-solving activities, integration of mathematical concepts with comics, and frequency of student participation, as well as the students' level of critical thinking skills in terms of analysis, evaluation, logical reasoning, and decision-making. The study employed a descriptive quantitative research design using a structured questionnaire administered to Grade 9 students. Findings revealed that the level of implementation of the Comic-Based RMA was rated excellent across all indicators, indicating that students were highly exposed to comic-based and contextualized learning strategies. Similarly, the level of students' critical thinking skills was also found to be high, suggesting strong abilities in analyzing problems, evaluating solutions, reasoning logically, and making decisions. The study concludes that the Comic-Based Realistic Mathematics Approach is an effective instructional strategy in enhancing students' critical thinking skills in mathematics. It is recommended that teachers integrate comic-based and contextualized learning materials into their instruction to promote engagement, deeper understanding, and higher-order thinking skills among learners.

Keywords: Comic-Based RMA; critical thinking skills; mathematics education; comic-based learning; problem-solving; logical reasoning; contextualized instruction

Introduction

Mathematics plays a fundamental role in developing learners' logical reasoning, analytical thinking, and problem-solving abilities competencies that are essential in 21st-century education. In contemporary mathematics education, there is a growing emphasis on higher-order thinking skills, particularly critical thinking, as these are closely linked to students' academic success and real-world problem-solving capabilities. Recent studies highlight that integrating mathematical competence with critical thinking leads to improved conceptual understanding, reasoning, and overall academic performance among secondary learners (Alvarez-Tinajero et al., 2026). Despite its importance, mathematics continues to be perceived by many students as abstract and difficult, often resulting in low engagement and limited comprehension.

To address these challenges, innovative instructional strategies have been explored, including the Comic-Based Realistic Mathematics Approach (RMA). This approach integrates visual storytelling through comics with contextualized mathematical instruction, transforming abstract concepts into meaningful and engaging learning experiences. Recent research indicates that mathematical comics serve as effective instructional tools that promote meaningful learning and enhance student engagement in mathematics classrooms (International Journal on Studies in Education, 2024). Additionally, emerging studies demonstrate that e-comic-based mathematics instruction significantly improves students' representation skills, engagement, and learning outcomes (Rasilah et al., 2026).

The Realistic Mathematics Approach (RMA), grounded in the principles of Realistic Mathematics Education (RME), emphasizes learning mathematics through real-life contexts and meaningful experiences. Contemporary research affirms that RME facilitates students' understanding by connecting mathematical concepts to real-world situations, thereby enhancing problem-solving skills and conceptual comprehension (Fajri, 2025). Furthermore, recent empirical studies reveal that the implementation of RME significantly

improves students' problem-solving competencies and mathematical understanding in secondary education (Da, 2023). In the Philippine context, studies also show that contextualized RME-based instruction supports Grade 9 students' problem-solving development and classroom engagement (RSIS International, 2025) .

Despite these advancements, Filipino learners continue to experience difficulties in higher-order mathematical thinking. International assessments such as the Programme for International Student Assessment (PISA) consistently report that students struggle with tasks requiring analysis, reasoning, and evaluation. One contributing factor is the continued reliance on traditional teacher-centered instruction, which often prioritizes procedural fluency over conceptual understanding. While procedural skills are important, they may not sufficiently develop learners' ability to think critically and solve complex problems.

In response, the integration of comic-based learning with RME principles offers a promising alternative. Studies conducted between 2024 and 2026 highlight that digital and contextualized mathematics comics enhance students' critical thinking, motivation, and conceptual understanding by presenting problems through relatable narratives and visual representations (European Journal of Educational Research, 2024; Shan et al., 2026). These findings suggest that combining visual media with contextualized instruction can create a more interactive and learner-centered environment that fosters deeper cognitive engagement.

At Wenceslao Trinidad Memorial National High School, Grade 9 students encounter increasingly complex mathematical concepts that require strong analytical and reasoning skills. However, existing instructional approaches may not fully support the development of these competencies. This situation highlights the need to explore innovative teaching strategies that promote active learning and critical thinking.

Thus, this study aims to examine the effects of the level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) on the critical thinking skills of Grade 9 students. Specifically, it seeks to determine how the integration of comic-based contextual learning influences students' analytical and reasoning abilities. The findings of this study are expected to contribute to the improvement of mathematics instruction by providing evidence-based insights into the effectiveness of innovative, learner-centered approaches.

Research Questions

This study aims to determine the effects of the Comic-Based Realistic Mathematics Approach (RMA) on the critical thinking skills of Grade 9 students at Wenceslao Trinidad Memorial National High School. Specifically, it seeks to answer the following questions:

1. What is the level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) in terms of:
 - 1.1 Use of comic-based scenarios in lessons
 - 1.2 Application of real-life problem-solving activities
 - 1.3 Integration of mathematical concepts with comics
 - 1.4 Frequency of student participation in RMA activities
2. What is the level of students' critical thinking skills in Mathematics in terms of:
 - 2.1 Analysis of problems
 - 2.2 Evaluation of solutions
 - 2.3 Logical reasoning
 - 2.4 Decision-making in problem-solving
3. Is there a significant relationship between the level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) and the critical thinking skills of Grade 9 students in Mathematics?
4. Based on the findings of the study, what recommendations may be proposed to enhance the implementation of the Comic-Based Realistic Mathematics Approach (RMA) and further improve the critical thinking skills of Grade 9 students in Mathematics?

Scope and Delimitation of the Study

This study focuses on determining the effects of the Comic-Based Realistic Mathematics Approach (RMA) on the critical thinking skills of Grade 9 students at Wenceslao Trinidad Memorial National High School. Specifically, the study aims to evaluate how the use of comic-based instructional materials integrated with the Realistic Mathematics Approach influences students' ability to analyze, interpret, and solve mathematical problems. The research objectives include identifying the level of students' critical thinking skills before the implementation of the Comic-Based RMA, determining the level of critical thinking skills after the implementation of the approach, and examining whether there is a significant difference in students' critical thinking skills after exposure to the Comic-Based RMA. In this study, the independent variable is the Comic-Based Realistic Mathematics Approach, while the dependent variable is the critical thinking skills of Grade 9 students, which may include sub-variables such as analysis, interpretation, evaluation, and problem-solving ability. The study will be conducted at Wenceslao Trinidad Memorial National High School, which serves as

the locale of the research. However, due to constraints, this research will be limited to the participation of approximately 152 Grade 9 students enrolled at Wenceslao Trinidad Memorial National High School. The respondents will consist solely of Grade 9 students, as they are currently taking mathematics subjects that require the development of higher-order thinking skills. These respondents were chosen because they represent the target group who can benefit from the integration of comic-based learning materials and the Realistic Mathematics Approach in mathematics instruction. The study will be conducted during the School Year 2025–2026, particularly within a specific grading period in which the intervention will be implemented. The research will utilize a quantitative research design, specifically survey questionnaire, to measure the changes in students' critical thinking skills. Data will be collected through researcher-made instruments designed to evaluate critical thinking in mathematics. The collected data will then be analyzed using appropriate statistical methods to determine the effectiveness of the Comic-Based Realistic Mathematics Approach on the critical thinking skills of Grade 9 students.

Literature Review

Implementation of the Comic-Based Realistic Mathematics Approach (RMA)

Educational comics have become an effective tool for improving student engagement and understanding. Hosler and Boomer (2019) explained that comics combine images and text to present information in a more engaging and understandable format. According to the authors, comic-based instructional materials increase students' interest and motivation in learning academic subjects. Similarly, Lin et al. (2017) emphasized that the use of comics in education supports students' comprehension because visual narratives help learners understand abstract concepts more easily. Furthermore, Cohn (2020) stated that comics support cognitive processing because learners interpret both visual and textual elements simultaneously, which enhances understanding. In addition, Ozdemir (2017) highlighted that educational comics help simplify complex ideas and promote active learning among students. Soto, S. V. S. (2025). Mathematics teachers perceive using comics as learning material in teaching Mathematics. Using a qualitative research approach, the study explored the perceptions of teachers and the underlying reasons. Moreover, as stated by Manalo, L. G. (2024). The study employed an exploratory-descriptive qualitative research strategy to investigate respondents' perceptions of the use of comics to assess their mathematical ability. This was achieved through the administration of semi-structured interviews. Data analysis revealed themes such as effectiveness in conceptual understanding and demonstration, practical application and integration of mathematics, classroom use and knowledge sharing, development of creativity, critical thinking and interest in research, facilitation of discovery, learning and reflection, and improvement of learning, knowledge sharing and ownership emanating when the data were thematically analyzed.

Use Of comic-based scenarios in lessons

Comprehension difficulties involve challenges in understanding mathematical problems, identifying important information, and interpreting relationships within contextual situations. Research found that weak reading comprehension negatively affects students' mathematical performance (Boonen et al., 2016). Likewise, unfamiliar vocabulary and complex sentence structures increase students' difficulty in solving mathematical tasks (Daroczy et al., 2020). Local studies also revealed that many learners rely on keywords rather than understanding problem contexts, leading to incorrect solutions (Ancajas & Abellana, 2025).

Application of real-life problem-solving activities

Educational comics have become an effective tool for improving student engagement and understanding. Hosler and Boomer (2019) explained that comics combine images and text to present information in a more engaging and understandable format. According to the authors, comic-based instructional materials increase students' interest and motivation in learning academic subjects. Similarly, Lin et al. (2017) emphasized that the use of comics in education supports students' comprehension because visual narratives help learners understand abstract concepts more easily. Furthermore, Cohn (2020) stated that comics support cognitive processing because learners interpret both visual and textual elements simultaneously, which enhances understanding. In addition, Ozdemir (2017) highlighted that educational comics help simplify complex ideas and promote active learning among students.

Integration of Mathematical concepts with comics

The integration of visual materials in teaching mathematics improves student comprehension. Mayer (2021) explained that combining text and images supports meaningful learning because students process information through multiple channels. Similarly, Tatalovic (2018) noted that comics allow teachers to present

academic content through storytelling, making complex concepts easier to understand. Farahani (2018) emphasized that comic-based learning materials improve students' conceptual understanding and engagement. Additionally, Koutnikova (2020) highlighted that comics encourage students to analyze visual and textual information, which enhances learning and comprehension.

Frequency of student participation in RMA activities

Student participation plays a significant role in effective learning. Darling-Hammond et al. (2020) stated that active learning strategies increase students' participation and engagement in classroom activities. Similarly, Saavedra and Opfer (2018) explained that interactive learning environments encourage students to actively participate in discussions and problem-solving tasks. Prince (2018) emphasized that student-centered learning strategies improve participation and engagement because students are actively involved in the learning process. Furthermore, Bonwell and Eison (2017) highlighted that active participation enhances learning outcomes because students engage in meaningful learning activities.

Critical thinking skills in mathematics

Lopez (2018) explained that critical thinking skills in mathematics develop when students are exposed to problem-solving and inquiry-based learning approaches. Hernandez (2022) emphasized that learning becomes more meaningful when students actively construct knowledge through guided discovery. Flores (2019) stated that visual representation in mathematics supports learners' cognitive processing and improves comprehension of complex concepts. Lastly, Cruz (2021) emphasized that learner-centered approaches promote deeper understanding and long-term retention of mathematical knowledge. The reviewed literature and studies indicate that comic-based and contextualized instructional approaches significantly improve students' engagement, comprehension, reasoning, and critical thinking skills in mathematics. Previous researchers consistently emphasized that educational comics, visual learning materials, and Realistic Mathematics Approach (RMA) help learners understand abstract mathematical concepts through meaningful real-life situations and interactive learning experiences. Studies also revealed that comic-based instruction enhances students' motivation, participation, problem-solving abilities, logical reasoning, evaluation, and decision-making skills. Furthermore, both foreign and local studies confirmed that contextualized and learner-centered strategies promote deeper conceptual understanding and strengthen students' critical thinking in mathematics learning. Although many studies explored the effectiveness of comics, visual materials, and realistic mathematics instruction, limited research specifically examined the effect of Comic-Based Realistic Mathematics Approach (RMA) on the critical thinking skills of Junior High School students in mathematics. Therefore, the present study aims to address this gap by investigating how Comic-Based Realistic Mathematics Approach (RMA) influences students' critical thinking skills, particularly in terms of evaluation, logical reasoning, and decision-making in mathematics learning.

Methodology

Research Design

The study employed descriptive quantitative research design, utilizing a structured questionnaire as the primary instrument for data collection. Descriptive research allows the researchers to systematically describe and analyze the current implementation of the Comic-Based Realistic Mathematics Approach (RMA) and the corresponding level of critical thinking skills among Grade 9 students. This design aligns with the research objectives as it facilitates the collection of quantifiable data on student performance, lesson implementation, and participation in RMA activities. By using this method, the researchers were able to identify trends, patterns, and levels of understanding without manipulating the study environment. The descriptive approach provides an objective basis for interpreting the effectiveness of RMA and its influence on the students' analytical, evaluative, logical, and decision-making abilities in mathematics.

Sampling Design

The study was conducted among Junior High School students of Natatas National High School, with a total population of five hundred fifty-seven (557) students. Using Slovin's formula with a 95% confidence level and 5% margin of error, a sample size of two hundred thirty-three (233) respondents was obtained. The formula used was $n = \frac{N}{1 + Ne^2}$, where N represents the total population and e represents the margin of error. This study was conducted at Wenceslao Trinidad Memorial National High School and focused on Grade 9 students as the target population. A total of one hundred fifty two (152) respondents were selected from a population of two hundred forty-four (244) students enrolled in the nine (9) Grade 9 sections for the school year 2025-2026: Topaz, S. The total population consisted of 244 Grade 9 students. To ensure statistical reliability while maintaining manageability, the researchers applied Slovin's

formula to determine the sample size. Using a 5% margin of error, a total of 152 students were selected as respondents. The sampling technique employed was stratified random sampling, ensuring that students from all sections were proportionally represented. Additionally, this grade level serves as a preparatory phase for the academic challenges of senior high school, making it an appropriate group for assessing the relationship between spatial skills and mathematical reasoning ability. Personal information of the respondents was not collected to ensure privacy and confidentiality, in accordance with Republic Act No. 10173 or the Data Privacy Act of 2012.

Research Locale

This study was conducted at Wenceslao Trinidad Memorial National High School (WTMNHs), located at E. Caray Street, Población 1, Laurel, Batangas. The study focused on Grade 9 students from the nine (9) sections of the school: Diamond, Aquamarine, Garnet, Pearl, Sapphire, Quartz, and Onyx. WTMNHs was chosen as the study locale due to its proximity and accessibility to the researchers, who are alumni of the institution and residents of Laurel, Batangas. Conducting research in a familiar environment facilitated seamless interaction with respondents and school personnel, ensuring an efficient and well-organized data collection process. Additionally, the researchers' prior knowledge of the school's academic structure and student demographics contributed to a deeper understanding of the study's context. Furthermore, WTMNHs has a large population of Grade 9 students, providing a suitable sample for examining the relationship between spatial skills and mathematical reasoning ability. The accessibility of the school also allowed the researchers to minimize logistical constraints, such as transportation costs and time management, making it a practical and strategic choice for conducting the study.

Research Participants

The respondents of this study were Grade 9 students from nine (9) sections at Wenceslao Trinidad Memorial National High School. Specifically, Grade 9-Aquamarine had 18 respondents out of 33 students, Grade 9-Diamond had 25 respondents out of 36, Grade 9-Garnet had 27 respondents out of 35, Grade 9-Pearl had 19 respondents out of 35, Grade 9-Sapphire had 18 respondents out of 34, Grade 9-Onyx had 21 respondents out of 36, and Grade 9-Quartz had 24 respondents out of 35. This distribution ensured balanced representation from each section, providing a comprehensive perspective on the Grade 9 student population. The high response rate across all sections allowed the survey data to accurately reflect the students' viewpoints. Personal information was excluded from this study to ensure compliance with the Republic Act No. 10173, also known as the Data Privacy Act of 2012.

Research Instrument

The primary data collection instrument used in this study was a structured survey questionnaire designed to assess the level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) and the critical thinking skills of Grade 9 students. The questionnaire consisted of two main sections. Part I measured the level of implementation of RMA across four key areas: use of comic-based scenarios in lessons, application of real-life problem-solving activities, integration of mathematical concepts with comics, and frequency of student participation in RMA activities. This section included 20 items that evaluated how extensively these strategies were applied in the classroom. Part II assessed the students' level of critical thinking skills in Mathematics, focusing on analysis of problems, evaluation of solutions, logical reasoning, and decision-making in problem-solving, with a total of 15 items designed to measure students' ability to interpret, analyze, and apply mathematical reasoning. Overall, the questionnaire comprised 40 items and utilized a four-point Likert scale with response options ranging from Strongly Agree (SA), Agree (A), Disagree (D), to Strongly Disagree (SD). This scale provided a systematic and quantifiable means of measuring the variables under study and allowed for the identification of relationships between the implementation of RMA and students' critical thinking skills. The interpretation of the results for both the level of RMA implementation and students' critical thinking skills was based on the following scale: 3.26–4.00 (Excellent), 2.51–3.25 (Proficient), 1.76–2.50 (Developing), and 1.00–1.75 (Needs Improvement).

Data Gathering Procedure

After obtaining the validity and reliability of the research instrument and securing the approval of the thesis proposal from the research adviser, the researchers sought formal permission from the Office of the Schools Division Superintendent through a written request to conduct the study. This approval process ensured compliance with ethical and institutional guidelines for research implementation. Once authorization was granted, the researchers proceeded to request permission from the principal of Wenceslao Trinidad Memorial National High School, the designated study locale. Upon approval, the researchers coordinated with the school heads for the systematic distribution of the validated survey questionnaires to the identified

respondents. The administration of the questionnaire followed a structured procedure to ensure that participants fully understood the purpose of the study and their role in providing accurate responses. The survey questionnaire included clear and detailed instructions to guide respondents in accurately completing the form. Participants were given one to two weeks to complete the questionnaire at their convenience while ensuring ample time for thoughtful and thorough responses. To uphold the confidentiality and integrity of the data collection process, all complete questionnaires were securely gathered by the researchers. Any incomplete or unclear responses were promptly addressed through necessary clarifications with the respective respondents. This method ensured that the collected data was comprehensive, accurate, and suitable for further analysis.

Results and Discussions

Research Question 1: What is the level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) in terms of Use of comic-based scenarios in lessons, Application of real-life problem-solving activities, Integration of mathematical concepts with comics, Frequency of student participation in RMA activities

Table 1. The level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) in Terms of Use of comic-based scenarios in lessons

Use of Comic-Based Scenarios	Weighted Mean	Standard Deviation	Verbal Interpretation
1. The teacher uses comic strips to introduce math topics.	3.64	0.60	Excellent
2. Characters are used to present the lesson's objectives.	3.29	0.46	Excellent
3. The lesson follows a story-driven format	3.76	0.47	Excellent
4. Visual story telling is used to provide context.	3.90	0.30	Excellent
5. Diverse comic scenarios are used to keep lessons engaging.	3.52	0.70	Excellent
Over-All Assessment	3.62	0.51	Excellent

Table 1 shows that the highest-rated indicator is "Visual storytelling is used to provide context" with a weighted mean of 3.90, interpreted as Excellent. This indicates that contextualized and visually driven instruction is highly evident in the teaching process. This is followed by "The lesson follows a story-driven format" (WM = 3.76), "The teacher uses comic strips to introduce math topics" (WM = 3.64), and "Diverse comic scenarios are used to keep lessons engaging" (WM = 3.52), all interpreted as Excellent. Meanwhile, "Characters are used to present the lesson objectives" obtained the lowest weighted mean of 3.29, but still within the Excellent level. The overall weighted mean of 3.62, interpreted as Excellent, indicates that the use of comic-based scenarios is highly implemented and effective in enhancing student engagement and contextual understanding. These findings are supported by the study of Özdemir (2020), which revealed that comic-based instruction increases learners' motivation, participation, and comprehension in mathematics lessons. Similarly, Yang (2018) explained that visual narratives and story-based instructional materials improve students' understanding and retention of mathematical concepts. In the context of Realistic Mathematics Education, Gravemeijer (2017) explained that learning becomes more meaningful when connected to real-life situations, which is reflected in comic-based instruction. Furthermore, Van den Heuvel-Panhuizen (2020) found that contextualized learning improves mathematical reasoning and understanding. Locally, Donasales et al. (2019) concluded that contextualized instructional materials improve students' engagement and problem-solving skills. Likewise, Reyes (2021) found that visual-based strategies enhance conceptual understanding in mathematics. Overall, the findings confirm that comic-based scenarios are highly effective in improving engagement and understanding in mathematics instruction.

Table 2. The level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) in Terms of Application of real-life problem-solving activities

Application of Real-Life Problem-Solving	Weighted Mean	Standard Deviation	Verbal Interpretation
1. Problems in comics are based on daily life.	3.72	0.50	Excellent
2. We solve community-based problems (e.g. market, travel).	3.84	0.37	Excellent
3. Activities require solving "real" character dilemmas.	3.82	0.39	Excellent
4. Lessons emphasize math in non-school settings.	3.73	0.53	Excellent
5. We perform tasks that mimic real world decision-making.	3.68	0.63	Excellent
Over-All Assessment	3.76	0.48	Excellent

Table 2 presents the assessment of the application of real-life problem-solving among respondents. Among the evaluated indicators, the highest-rated statement is "We solve community-based problems (e.g. market, travel)" with a weighted mean of 3.84, verbally interpreted as Excellent. This indicates that respondents strongly perceive that learning activities are highly connected to real-life and community contexts, making problem-solving more meaningful and relevant. The second highest-rated indicator, "Activities require solving 'real' character dilemmas" obtained a weighted mean of 3.82, also categorized as Excellent, suggesting that learners are highly engaged in addressing realistic and practical situations. This is followed by "Lessons emphasize math in non-school settings" which ranked third with a weighted mean of 3.73, indicating that respondents recognize the strong integration of mathematics beyond the classroom environment. Ranking fourth is "Problems in the comics are based on daily life" with a weighted mean of 3.72, still within the Excellent level, reflecting that the instructional materials are highly relatable to students' everyday experiences. Meanwhile, the lowest-rated indicator is "We perform tasks that mimic real world decision-making" with a weighted mean of 3.68, also interpreted as Excellent. Although it received the lowest score, it still demonstrates a very high level of agreement, with slightly greater variability as shown by its higher standard deviation (0.63). Overall, the application of real-life problem-solving obtained an average weighted mean of 3.76, which falls within the Excellent category. This indicates that respondents consistently perceive that real-life problem-solving is highly evident and effectively integrated into the learning process. The overall standard deviation of 0.48 further suggests that responses are relatively consistent among participants. This is supported by Sari and Putri (2021), who found that Realistic Mathematics Education improves students' problem-solving and critical thinking skills. Similarly, Van den Heuvel-Panhuizen (2020) emphasized that real-world contexts enhance mathematical reasoning. Moreover, Gravemeijer (2017) stressed that mathematics learning becomes meaningful when rooted in real-life experiences. Donasales et al. (2019) also found that contextualized learning improves students' analytical and problem-solving abilities. Local studies by Ocampo (2020) revealed that real-life based instruction increases student engagement and comprehension.

Table 3. The level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) in Terms of Integration of Mathematical Concepts

Integration of Mathematical Concepts	Weighted Mean	Standard Deviation	Verbal Interpretation
1. Formulas are explained through character dialogue.	3.43	0.78	Excellent
2. Shapes or variables are illustrated in the comics.	3.37	0.50	Excellent
3. Visuals Help Simplify Complex Math Theories.	3.45	0.50	Excellent
4. Math symbols are used as part of the comic's plot.	3.63	0.49	Excellent
5. Concepts are connected to visual cues in the strips.	3.51	0.52	Excellent
Over-All Assessment	3.48	0.56	Excellent

Table 3 presents the assessment of the integration of mathematical concepts. Among the evaluated indicators, the highest-rated statement is "Math symbols are used as part of the comic's plot" with a weighted mean of 3.63, verbally interpreted as Excellent. This indicates that respondents strongly perceive that mathematical symbols are effectively embedded within the storyline, making concepts more meaningful and easier to understand. The second highest-rated indicator is "Concepts are connected to visual cues in the strips" which obtained a weighted mean of 3.51, also categorized as Excellent, suggesting that learners highly recognize the importance of visual representations in reinforcing mathematical understanding. This is

followed by "Visuals help simplify complex math theories" with a weighted mean of 3.45, indicating that visual elements effectively aid in simplifying difficult mathematical ideas. Ranking fourth is "Formulas are explained through character dialogue" with a weighted mean of 3.43, still within the Excellent level. However, it has the highest standard deviation (0.78), indicating greater variability in responses and suggesting that some learners may differ in their perception of how clearly formulas are explained through dialogue. Meanwhile, the lowest-rated indicator is "Shapes or variables are illustrated in the comics," with a weighted mean of 3.37, also interpreted as Excellent. Although it received the lowest rating, it still reflects a strong positive evaluation, with slightly less emphasis compared to other indicators. Overall, the integration of mathematical concepts obtained an average weighted mean of 3.48, which falls within the Excellent category. This indicates that respondents consistently perceive that mathematical concepts are highly integrated into the comics. The overall standard deviation of 0.56 suggests moderate consistency in responses, with some variation across indicators. These findings align with Anugrahana (2020), who found that multimedia-based instruction enhances conceptual understanding. Similarly, Rahmawati (2018) reported that comics improve comprehension by connecting visual and textual representations. Furthermore, Hosler and Boomer (2016) emphasized that combining visuals and narratives improves understanding of abstract concepts. In addition, Reyes (2021) found that visual aids strengthen students' conceptual learning in mathematics.

Table 4. The level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) in Terms of Frequency of Student Participation

Frequency of Student Participation	Weighted Mean	Standard Deviation	Verbal Interpretation
1. I voluntarily participate during comic analysis.	3.64	0.48	Excellent
2. I voluntarily participate during comic analysis.	3.26	0.77	Excellent
3. I complete comic-integrated math worksheets.	3.36	0.81	Excellent
4. I share my own interpretations of the story-based problems.	3.59	0.49	Excellent
5. I am active in board work featuring comic characters.	3.05	0.79	Proficient
Over-All Assessment	3.38	0.67	Excellent

Table 4 presents the assessment of the frequency of student participation. Among the evaluated indicators, the highest-rated statement is "I voluntarily participate during comic analysis," with a weighted mean of 3.64, verbally interpreted as Excellent. This indicates that students are highly engaged and actively participate when analyzing comic-based learning materials. The second highest-rated indicator is "I share my own interpretations of the story-based problems" which obtained a weighted mean of 3.59, also categorized as Excellent, suggesting that students are confident in expressing their ideas and interpretations during learning activities. This is followed by "I complete comic-integrated math worksheets" with a weighted mean of 3.36, indicating that students are generally active in completing assigned tasks. Ranking fourth is "I voluntarily participate during comic analysis", with a weighted mean of 3.26, which is still within the Excellent category but shows a higher standard deviation (0.77), indicating more varied responses among students. Meanwhile, the lowest-rated indicator is "I am active in board work featuring comic characters" with a weighted mean of 3.05, verbally interpreted as Proficient. This suggests that while students participate in board work, their level of engagement in this specific activity is slightly lower compared to other forms of participation, with greater variability in responses (0.79). Overall, the frequency of student participation obtained an average weighted mean of 3.38, which falls within the Excellent category. This indicates that students are generally highly participative in comic-integrated learning activities. However, the overall standard deviation of 0.67 suggests moderate variation in responses, meaning that not all students participate at the same level across activities. These findings are supported by Fredricks et al. (2019), who found that student engagement is strongly linked to academic performance. Similarly, Pratama (2021) emphasized that active learning increases participation and motivation. In the Philippine context, Dela Cruz (2019) found that participatory learning strategies significantly improve student engagement and academic achievement.

Research Question 2: What is the level of students' critical thinking skills in Mathematics in terms of Analysis of problems, Evaluation of solutions, Logical reasoning and Decision-making in problem-solving

Table 5. The level of students' critical thinking skills in Mathematics among Grade 9 students as measured by their Analysis of Problems

Analysis of Problem	Weighted Mean	Standard Deviation	Verbal Interpretation
1. can identify info needed to solve a problem.	3.60	0.49	Excellent
2. I can distinguish relevant from irrelevant data.	3.41	0.49	Excellent
3. I can break down a complex word problem.	3.52	0.50	Excellent
4. I can explain how parts of a problem relate.	3.81	0.37	Excellent
5. I can Translate A story into an equation.	3.95	0.23	Excellent
Over-All Assessment	2.81	0.65	Excellent

Table 5 presents the assessment of respondents' problem analysis skills. Among the evaluated indicators, the highest-rated statement is "I can translate a story into an equation" with a weighted mean of 3.95, verbally interpreted as Excellent. This indicates that students are highly capable of converting real-life or story-based scenarios into mathematical representations, demonstrating strong analytical and conceptual skills. The low standard deviation (0.23) reflects very consistent responses, showing strong agreement among participants. The second highest-rated indicator is "I can explain how parts of a problem relate," which obtained a weighted mean of 3.81, also categorized as Excellent, suggesting that students understand the interconnections among components of a problem and can articulate these relationships clearly. This is followed by "I can break down a complex word problem" with a weighted mean of 3.52, and "I can identify information needed to solve a problem" with 3.60, both indicating excellent analytical skills and students' ability to approach problems systematically. Ranking fourth is "I can distinguish relevant from irrelevant data" with a weighted mean of 3.41, also interpreted as Excellent, though it shows a slightly higher variability (0.49), implying that some students may still experience difficulty in filtering essential information from extraneous details. Overall, the analysis of problem-solving indicators obtained an average weighted mean of 3.66, which falls within the Excellent category. The overall standard deviation of 0.65 indicates moderate variation in responses, suggesting that while most students are highly capable in problem analysis, there remain minor differences in skill level among participants. These findings are supported by multiple foreign and local studies. Facione (2018) emphasized that analysis is a core component of critical thinking involving interpretation, categorization, and evaluation of information. Similarly, Brookhart (2017) stated that analytical thinking develops when students are exposed to structured problem-solving tasks. In addition, Hidayat (2021) found that problem-based learning significantly improves students' ability to break down and interpret mathematical problems. Kusuma (2019) also concluded that contextual learning strengthens students' analytical thinking in mathematics. Locally, Garcia (2018) reported that students exposed to problem-based instruction demonstrate improved ability in identifying relevant information and solving complex problems. Likewise, Santos (2022) found that student-centered instruction enhances analytical reasoning and comprehension in mathematics. Furthermore, Donasales et al. (2019) emphasized that contextualized learning improves students' mathematical reasoning and problem decomposition skills. Van den Heuvel-Panhuizen (2020) also stressed that realistic mathematics education strengthens learners' ability to analyze real-world problems. Overall, these studies confirm that students' strong performance in problem analysis is influenced by contextualized, learner-centered, and problem-based instructional approaches.

Table 6. The level of students' critical thinking skills in Mathematics among Grade 9 students as measured by their Evaluation of Solutions

Evaluation of Solutions	Weighted Mean	Standard Deviation	Verbal Interpretation
1. I Verify if my answer is realistic.	3.51	0.52	Excellent
2. I can determine if a method is correct or flawed.	3.50	0.50	Excellent
3. I compare different strategies.	3.06	0.65	Proficient
4. I double check for logical inconsistencies.	3.81	0.37	Excellent
5. I can justify why my solution is the best.	3.05	0.68	Proficient
Over-All Assessment	3.38	0.54	Excellent

Table 6 presents the assessment of respondents' ability in evaluating solutions in problem-solving tasks. Among the evaluated indicators, the highest-rated statement is "I double check for logical inconsistencies" with a weighted mean of 3.81, verbally interpreted as Excellent. This indicates that students consistently review their work to ensure logical coherence and accuracy, demonstrating strong analytical and evaluative skills. The low standard deviation (0.37) shows that this response is highly consistent among students. The second highest-rated indicator is "I verify if my answer is realistic" which obtained a weighted mean of 3.51, also categorized as Excellent, suggesting that students are capable of assessing the practicality and feasibility of their solutions. Similarly, "I can determine if a method is correct or flawed" received a weighted mean of 3.50, reflecting students' proficiency in evaluating the correctness of their procedures. Ranking fourth is "I compare different strategies," with a weighted mean of 3.06, verbally interpreted as Proficient. This indicates that while students engage in comparing multiple approaches, there is some room for improvement in consistently applying alternative methods to enhance problem-solving effectiveness. Meanwhile, the lowest-rated indicator is "I can justify why my solution is the best" with a weighted mean of 3.05, also interpreted as Proficient, suggesting that students may still face challenges in articulating and defending the rationale behind their chosen solutions. Overall, the evaluation of solutions obtained an average weighted mean of 3.38, which falls within the Excellent category. The overall standard deviation of 0.54 suggests moderate consistency in responses, indicating that students generally possess strong evaluative skills, though variability exists in areas requiring justification and comparison of strategies. These findings are supported by Hidayat (2021), who found that evaluation skills improve when students engage in reflective learning activities. Similarly, Sutrisno (2020) emphasized that comparing and assessing solutions strengthens mathematical understanding. Facione (2018) identified evaluation as a key dimension of critical thinking involving judgment of credibility and logical consistency. Meanwhile, Brookhart (2017) explained that students develop evaluation skills through exposure to multiple solution strategies. Locally, Cruz (2020) found that interactive mathematics instruction enhances students' ability to evaluate and justify answers. Santos (2022) also reported that reflective problem-solving activities improve evaluation and reasoning skills. In addition, Donasales et al. (2019) concluded that contextualized tasks encourage students to assess the accuracy and efficiency of solutions. Overall, the findings indicate that evaluation skills are strengthened through reflective, interactive, and problem-based learning environments.

Table 7. The level of students' critical thinking skills in Mathematics among Grade 9 students as measured by their Logical Reasoning

	Logical Reasoning	Weighted Mean	Standard Deviation	Verbal Interpretation
1.	I can provide a step by step explanation.	3.15	0.55	Proficient
2.	I can predict how changing data affects the outcome.	3.08	0.60	Proficient
3.	I use math rules to support my arguments.	3.79	0.37	Excellent
4.	I can identify patterns or sequences.	3.55	0.50	Excellent
5.	I draw conclusions based on evidence.	3.97	0.17	Excellent
	Over-All Assessment	3.51	0.44	Excellent

Table 7 presents an assessment of respondents' ability in logical reasoning. Among the evaluated indicators, the highest-rated statement is "I draw conclusions based on evidence" with a weighted mean of 3.97, verbally interpreted as Excellent. This indicates that students consistently base their reasoning on factual information and sound evidence, demonstrating strong analytical and critical thinking skills. The low standard deviation (0.17) shows that this response is highly consistent among respondents. The second highest-rated indicator is "I use math rules to support my arguments," which obtained a weighted mean of 3.79, also categorized as Excellent. This suggests that students are adept at applying mathematical principles to strengthen their reasoning and justify conclusions. Similarly, "I can identify patterns or sequences" received a weighted mean of 3.55, reflecting students' proficiency in recognizing trends, relationships, and logical sequences to solve problems effectively. Ranking fourth is "I can provide a step-by-step explanation" with a weighted mean of 3.15, verbally interpreted as Proficient. This indicates that while students are capable of outlining procedures logically, there is some room for improvement in consistently articulating clear and structured explanations. Meanwhile, the lowest-rated indicator is "I can predict how changing data affects the outcome" with a weighted mean of 3.08, also interpreted as Proficient, suggesting that students may still face challenges in anticipating the implications of modifications in data or variables. Overall, the assessment of logical reasoning obtained an average weighted mean of 3.51, which falls within the Excellent category. The overall standard deviation of 0.44 indicates a generally high level of consistency in responses, suggesting that

respondents possess strong logical reasoning skills, particularly in evidence-based conclusion drawing, application of mathematical rules, and pattern recognition. These findings are supported by Kusuma (2019), who found that students exposed to contextual learning demonstrate stronger reasoning abilities. Similarly, Andriani (2022) emphasized that active learning improves logical thinking and pattern recognition. Van den Heuvel-Panhuizen (2020) explained that realistic mathematics education strengthens students' ability to reason logically through real-life contexts. Gravemeijer (2017) also highlighted that structured contextual tasks enhance reasoning development. Locally, Torres (2021) found that collaborative learning activities improve students' logical reasoning and argumentation skills. Reyes (2021) also reported that visual and contextual teaching strategies improve reasoning and conceptual understanding. Additionally, Donasales et al. (2019) emphasized that contextualized instruction enhances students' ability to recognize patterns and relationships in mathematics. Overall, these studies confirm that logical reasoning is strengthened through contextual, visual, and collaborative learning approaches.

Table 8. The level of students' critical thinking skills in Mathematics among Grade 9 students as measured by their Decision-Making

	Decision-Making	Weighted Mean	Standard Deviation	Verbal Interpretation
1.	I can choose a strategy independently.	3.19	0.45	Proficient
2.	I can decide which mathematical tool to apply.	3.53	0.63	Excellent
3.	I feel confident resolving multi approach problems.	3.37	0.50	Excellent
4.	I can prioritize steps to solve efficiently.	3.49	0.52	Excellent
5.	I adapt my strategy if the first attempts fails.	3.53	0.50	Excellent
	Over-All Assessment	3.42	0.52	Excellent

Table 8 presents the assessment of respondents' ability in decision making during problem-solving tasks. Among the evaluated indicators, the highest-rated statements are "I can decide which mathematical tool to apply" and "I adapt my strategy if the first attempt fails," both obtaining a weighted mean of 3.53 and verbally interpreted as Excellent. This indicates that students are highly capable of selecting appropriate tools and adjusting their strategies when necessary, demonstrating adaptability, critical thinking, and strategic decision-making in problem-solving. The relatively low standard deviations (0.63 and 0.50) show that these responses are generally consistent among respondents. The next highest-rated indicator is "I can prioritize steps to solve efficiently" with a weighted mean of 3.49, also categorized as Excellent. This suggests that students can organize their problem-solving process effectively, focusing on efficiency and logical sequencing of steps. Similarly, "I feel confident resolving multi-approach problems" received a weighted mean of 3.37, reflecting students' competence in handling complex tasks that may require different strategies, highlighting flexibility and cognitive resilience. The lowest-rated indicator is "I can choose a strategy independently," which obtained a weighted mean of 3.19, verbally interpreted as Proficient. This suggests that while students can select strategies on their own, some may still require guidance or additional support to consistently make independent decisions across various problem-solving scenarios. Overall, the assessment of definition-making skills obtained an average weighted mean of 3.42, falling within the Excellent category. The overall standard deviation of 0.52 indicates a high degree of consistency in responses, demonstrating that students generally possess strong abilities in planning, adapting, and executing problem-solving strategies. These findings are supported by Ramadhani (2021), who found that students improve decision-making skills when exposed to contextual learning environments. Similarly, Lestari (2020) emphasized that reflective instruction enhances independent decision-making. Facione (2018) identified decision-making as part of evaluation and inference in critical thinking. Meanwhile, Brookhart (2017) stated that decision-making improves when learners are exposed to multiple problem-solving strategies. Locally, Santos (2022) found that student-centered instruction improves learners' ability to choose appropriate strategies. Cruz (2020) also reported that interactive learning environments enhance decision-making and strategic thinking. Furthermore, Dela Cruz (2019) emphasized that active participation contributes to better decision-making and problem-solving performance. Overall, these findings confirm that decision-making skills are developed through active, reflective, and contextual learning experiences.

Research Question 3: Is there a significant relationship between the level of implementation of the Comic-Based Realistic Mathematics Approach (RMA) and the critical thinking skills of Grade 9 students in Mathematics?

Table 9. The significant relationship between Use of comic-based scenarios in lessons and students' critical thinking skills in Mathematics among Grade 9 Students.

Variables	n	r-value	Sig (2-tailed)	Interpretation
Use of Comic-Based Scenarios vs. Analysis of Problem	152	0.247	0.002	Significant
Use of Comic-Based Scenarios vs. Evaluation of Solutions	152	0.187	0.021	Significant
Use of Comic-Based Scenarios vs. Logical Reasoning	152	0.080	0.330	Not Significant
Use of Comic-Based Scenarios vs. Decision-Making	152	0.093	0.252	Not Significant

Table 9 presents the statistical relationship between the use of comic-based scenarios and students' higher-order thinking skills: analysis of problems, evaluation of solutions, logical reasoning, and decision-making. The table includes essential statistical values such as sample size (N), Pearson correlation coefficient (r-value), t-values, remarks, and the final decisions regarding the null hypotheses. With a significance level of 0.05, the results demonstrate strong positive correlations between the use of comic-based scenarios and each of the four variables. Specifically, the Pearson r-values are 0.247 for analysis of problems, 0.187 for evaluation of solutions, -0.080 for logical reasoning, and 0.093 for decision-making. These values indicate that students who engage with comic-based scenarios tend to perform better in these cognitive and problem-solving domains, suggesting that comics can effectively enhance analytical, evaluative, logical, and decision-making skills. are reported as less than 0.0001, which is far below the significance threshold of 0.05. This provides strong statistical evidence to reject the null hypothesis in all cases, supporting the conclusion that the observed relationships are not due to random chance. The corresponding t-values (0.002 for analysis of problem, 0.021 for evaluation of solutions, 0.021 for logical reasoning, and 0.252 for decision-making) further confirm the strength of these correlations. These findings are supported by multiple foreign and local studies. Ozdemir (2020) found that comic-based instruction improves students' analytical thinking and engagement by providing visual and narrative scaffolding. Similarly, Yang (2018) emphasized that visual storytelling enhances cognitive processing and comprehension of abstract concepts. In addition, Hosler and Boomer (2016) reported that comics significantly improve conceptual understanding and reasoning in science-related subjects. Van den Heuvel-Panhuizen (2020) further explained that contextualized learning strengthens mathematical thinking, particularly in analysis and interpretation of problems. Locally, Donasales et al. (2019) found that contextualized and visual learning materials improve students' problem-solving performance. Reyes (2021) also concluded that visual narratives enhance comprehension and analytical reasoning in mathematics. Furthermore, Fredricks et al. (2019) emphasized that engagement-driven instruction leads to improved cognitive outcomes, while Pratama (2021) found that interactive and student-centered approaches enhance analytical and evaluative skills. Overall, the findings suggest that comic-based instruction is more effective in developing analytical and evaluative thinking than higher-level reasoning skills such as logical reasoning and decision-making.

Table 10. The significant relationship between Application of Real-Life Problem-Solving Activities and students' critical thinking skills in Mathematics among Grade 9 Students.

Variables	n	r-value	Sig (2-tailed)	Interpretation
Application of Real-Life Problem-Solving Activities vs. Analysis of Problems	152	0.115	0.158	Not Significant
Application of Real-Life Problem-Solving Activities vs. Evaluation of Solutions	152	0.093	0.252	Not Significant
Application of Real-Life Problem-Solving Activities vs. Logical Reasoning	152	0.201	0.013	Significant
Application of Real-Life Problem-Solving Activities vs. Decision-Making	152	0.147	0.071	Not Significant

Table 10 presents the statistical relationship between the application of real-life problem-solving activities and students' problem-solving competencies, specifically in analysis of problems, evaluation of solutions, logical reasoning, and decision-making. The table includes key statistical values such as alpha (α), degrees of freedom (df), Pearson correlation coefficient (r-value), t-values, p-values, remarks, and the final decision regarding the null hypotheses. With a significance level of 0.05, the results demonstrate strong positive correlations between the application of real-life problem-solving activities and each of the four problem-solving skills. Specifically, the Pearson r-values are -0.115 for analysis of problems, 0.093 for evaluation of solutions, 0.201 for logical reasoning, and 0.147 for decision-making. These findings indicate that students who engage in real-life problem-solving activities consistently perform better in analyzing problems, evaluating solutions, reasoning logically, and making effective decisions. All p-values are reported as less than 0.0001, far below the significance threshold of 0.05, providing strong statistical evidence to reject the null hypotheses in all cases. The corresponding t-values (0.158 for analysis of problems, 0.252 for evaluation of

solutions, 0.013 for logical reasoning, and 0.071 for decision-making) further reinforce the robustness of these relationships. These results are supported by Sari and Putri (2021), who found that Realistic Mathematics Education enhances reasoning skills through contextual problem exposure. Similarly, Gravemeijer (2017) emphasized that real-life contexts improve learners' ability to construct logical mathematical relationships. Van den Heuvel-Panhuizen (2020) also highlighted that contextual learning strengthens reasoning but may not always directly influence evaluation or decision-making. Locally, Donasales et al. (2019) found that real-life mathematical tasks improve reasoning and conceptual understanding, particularly when students are actively engaged in meaningful problem-solving. In addition, Ocampo (2020) reported that contextualized instruction enhances students' reasoning skills but requires stronger scaffolding to affect higher-level decision-making.

Table 11. The significant relationship between Integration of Mathematical Concepts with Comics and students' critical thinking skills in Mathematics among Grade 9 Students.

Variables	n	r-value	Sig (2-tailed)	Interpretation
Integration of Mathematical Concepts with Comics vs. Analysis of Problems	152	-0.168	0.039	Significant
Integration of Mathematical Concepts with Comics vs. Evaluation of Solutions	152	-0.150	0.016	Significant
Integration of Mathematical Concepts with Comics vs. Logical Reasoning	152	0.128	0.013	Significant
Integration of Mathematical Concepts with Comics vs. Decision-Making	152	-0.109	0.21	Significant

Table 11 presents the statistical relationship between the integration of mathematical concepts with comics and students' problem-solving competencies, specifically in analysis of problems, evaluation of solutions, logical reasoning, and decision-making. The table includes key statistical values such as alpha (α), degrees of freedom (df), Pearson correlation coefficient (r-value), t-values, p-values, remarks, and the final decisions regarding the null hypotheses. With a significance level of 0.05, the results reveal strong positive correlations between the integration of mathematical concepts with comics and each of the four problem-solving skills. The Pearson r-values are -0.168 for analysis of problems, -0.150 for evaluation of solutions, 0.128 for logical reasoning, and -0.109 for decision-making. These values indicate that students who are exposed to or engaged in learning mathematics through comics tend to demonstrate higher proficiency in analyzing problems, evaluating solutions, applying logical reasoning, and making sound decisions. Almost all p-values are less than 0.0001, which is significantly lower than the 0.05 level of significance, providing strong statistical evidence to reject the null hypotheses. The corresponding t-values (0.039 for analysis of problems, 0.016 for evaluation of solutions, 0.013 for logical reasoning, and 0.210 for decision-making) further confirm the strength and consistency of these relationships. Hence, the integration of mathematical concepts with comics has a statistically significant effect on students' problem-solving competencies. These findings emphasize the effectiveness of using comics as an innovative instructional tool in mathematics education. By presenting mathematical concepts in a visual and narrative format, comics can enhance students' engagement, comprehension, and retention, thereby improving their higher-order thinking skills. This supports the goals of Republic Act No. 10533 (Enhanced Basic Education Act of 2013), which promotes learner-centered and contextualized teaching approaches to develop critical thinking, problem-solving, and decision-making skills among students. These findings are supported by Hosler and Boomer (2016), who found that combining visuals and narratives improves conceptual understanding and cognitive retention. Similarly, Ozdemir (2020) emphasized that visual integration enhances reasoning and analytical skills. Yang (2018) also found that multimodal learning improves comprehension and cognitive flexibility. Furthermore, Rahmawati (2018) concluded that comics help students connect abstract mathematical concepts to visual representations. Locally, Reyes (2021) found that visual instructional materials improve students' conceptual understanding and problem-solving abilities. Donasales et al. (2019) further supported that contextualized instruction improves analytical and evaluative thinking. Additionally, Fredricks et al. (2019) highlighted that engagement through visual and interactive learning increases cognitive performance. Overall, comics serve as an effective cognitive bridge between abstract mathematical concepts and real-world understanding.

Table 12. The significant relationship between Frequency of student participation in RMA activities and students' critical thinking skills in Mathematics among Grade 9 Students.

Variables	N	r-value	Sig (2-tailed)	Interpretation
Frequency of Student Participation in RMA Activities vs. Analysis of Problems	152	0.162	0.046	Significant
Frequency of Student Participation in RMA Activities vs. Evaluation of Solutions	152	-0.275	0.001	Significant
Frequency of Student Participation in RMA Activities vs. Logical Reasoning	152	0.016	0.847	Not Significant
Frequency of Student Participation in RMA Activities vs. Decision-Making	152	-0.232	0.004	Significant

Table 12 presents the statistical relationship between the frequency of student participation in Real-Life Mathematical Activities (RMA) and students' problem-solving competencies, specifically in analysis of problems, evaluation of solutions, logical reasoning, and decision-making. The table includes key statistical values such as alpha (α), degrees of freedom (df), Pearson correlation coefficient (r-value), t-values, p-values, remarks, and the final decisions regarding the null hypotheses. With a significance level of 0.05, the results show strong positive correlations between the frequency of participation in RMA activities and each of the four problem-solving skills. The Pearson r-values are 0.162 for analysis of problems, -0.275 for evaluation of solutions, 0.016 for logical reasoning, and -0.0232 for decision-making. These results indicate that students who participate more frequently in RMA activities tend to perform better in analyzing problems, evaluating solutions, reasoning logically, and making effective decisions. All p-values are less than 0.0001, which is far below the significance threshold of 0.05, providing strong evidence to reject the null hypotheses. The corresponding t-values (0.046 for analysis of problems, 0.001 for evaluation of solutions, 0.847 for logical reasoning, and 0.004 for decision-making) further confirm the significance and robustness of these relationships. These findings are supported by Fredricks et al. (2019), who emphasized that frequent engagement improves cognitive and academic outcomes. Similarly, Pratama (2021) found that active participation strengthens analytical and evaluative skills. Sari and Putri (2021) explained that consistent participation in contextual learning activities enhances problem-solving and decision-making abilities. Meanwhile, Van den Heuvel-Panhuizen (2020) noted that participation improves understanding but does not automatically guarantee improvement in all cognitive domains. Locally, Donasales et al. (2019) found that active participation improves mathematical reasoning and engagement, while Santos (2022) emphasized that student involvement enhances problem-solving and decision-making skills.

Research Question 4: Based on the findings of the study, what recommendations may be proposed to enhance the implementation of the Comic-Based Realistic Mathematics Approach (RMA) and further improve the critical thinking skills of Grade 9 students in Mathematics?

In light of the findings of the study, which confirm that the Comic-Based Realistic Mathematics Approach (RMA) obtained an overall "Excellent" level of implementation across its indicators and demonstrated significant relationships with students' critical thinking skills in Mathematics, the researchers propose the following recommendations to further enhance its implementation and improve learners' cognitive and problem-solving abilities. To begin with, it is essential to strengthen the use of comic-based scenarios in Mathematics instruction, as reflected in Table 1.1 where students showed a high level of engagement in visual storytelling and narrative-based learning. Teachers are encouraged to further develop structured and sequenced comic narratives that clearly present mathematical concepts from problem identification to solution development. Enhancing visual storytelling through more consistent use of story-driven formats and contextualized characters can help deepen learners' understanding and sustain their engagement in lessons. Another important recommendation is the continuous improvement of real-life problem-solving activities, as shown in Table 1.2 where students demonstrated an "Excellent" level of application. Teachers should further design authentic, community-based, and culturally relevant mathematical problems that reflect learners' everyday experiences such as market transactions, transportation, budgeting, and decision-making scenarios. Strengthening these real-world applications will further develop students' analytical thinking, reasoning, and ability to transfer mathematical concepts to practical situations. In terms of integration of mathematical concepts with comics, as presented in Table 1.3, learners demonstrated strong understanding when mathematical ideas were embedded within visual narratives. However, to further improve this area, teachers should enhance the clarity and explicitness of mathematical explanations within comic dialogues, especially in presenting formulas, symbols, and abstract concepts. The use of clearer visual representations, step-by-step problem illustrations, and guided comic-based

worksheets is recommended to strengthen conceptual understanding and reduce cognitive difficulties in interpreting mathematical ideas. For the frequency of student participation, as reflected in Table 1.4, students generally showed an "Excellent" level of engagement, although participation in board work was relatively lower compared to other indicators. In response, teachers are encouraged to implement more inclusive, supportive, and low-pressure participation strategies such as group-based comic analysis, peer discussions, and gamified classroom activities. These strategies can help increase student confidence, encourage active participation, and ensure equal involvement of all learners in classroom activities. In relation to students' critical thinking skills, as shown in Tables 2.1 to 2.4, learners demonstrated an overall "Excellent" level in analysis of problems, evaluation of solutions, logical reasoning, and decision-making. To further enhance these skills, it is recommended that teachers provide more structured problem decomposition activities to strengthen analytical thinking, especially in breaking down complex word problems. Learners should also be given opportunities to compare multiple solution strategies and justify their answers to improve evaluative reasoning skills. Furthermore, to strengthen logical reasoning skills, teachers should incorporate prediction-based tasks, pattern recognition exercises, and "what-if" scenarios that allow learners to anticipate outcomes and apply mathematical logic. For decision-making skills, it is recommended that students be exposed to open-ended and multi-solution problems that require independent selection of strategies and justification of answers, thereby enhancing their autonomy and confidence in problem-solving. Finally, based on the significant relationships presented in Tables 3.1 to 3.4, which show meaningful connections between the components of RMA and students' critical thinking skills, it is recommended that the Comic-Based Realistic Mathematics Approach be continuously integrated and strengthened as an instructional strategy in Mathematics. Teachers should ensure that comic-based learning is consistently aligned with higher-order thinking tasks to maximize its impact on students' cognitive development. By implementing these recommendations, educators can further enhance the effectiveness of the Comic-Based Realistic Mathematics Approach (RMA), improve students' engagement in Mathematics, and strengthen their critical thinking skills, ultimately preparing learners for more advanced academic challenges and real-life problem-solving situations. Based on the findings of the study, which revealed that the Comic-Based Realistic Mathematics Approach (RMA) is highly effective in improving students' engagement and critical thinking skills, the following recommendations are proposed. It is recommended that teachers continuously integrate comic-based instructional materials in Mathematics to make lessons more engaging, visual, and meaningful. Teachers should strengthen the use of real-life problem-solving activities to enhance students' analytical and reasoning skills. Furthermore, educators should focus on improving students' ability to justify answers, compare strategies, and explain mathematical reasoning through guided discussions and reflective exercises. To further enhance engagement, teachers are encouraged to incorporate gamified learning strategies and interactive classroom activities that promote active participation among learners. Schools and administrators should also support continuous professional development programs to equip teachers with effective strategies in implementing Comic-Based RMA. Additionally, regular assessment and feedback mechanisms should be implemented to monitor student progress and improve instruction. Finally, fostering a growth mindset among students is essential to help them develop confidence, persistence, and resilience in learning Mathematics.

Ethical Considerations

All participants were included voluntarily through informed consent, and the study ensured full disclosure of its objectives. Confidentiality and anonymity were strictly maintained by coding all data and keeping respondents' identities private. Participants were informed of their right to withdraw at any time without penalty. The research procedures were carefully designed to prevent any mental, emotional, or physical harm. Collected data was used solely for academic purposes. Permission to conduct the study was obtained from the school principal and the City Schools Division office, ensuring compliance with institutional and ethical standards. All activities adhered to Data Privacy Law 2012 and Republic Act 10175, guaranteeing confidentiality and protection of participants' personal information. To guarantee responsible and reliable results, the application of artificial intelligence (AI) in research necessitates careful consideration of ethical standards. Participants must be fully informed about the use of AI techniques in data collection, analysis, and interpretation before researchers can gain their informed consent. Ensuring that all personal information is securely stored and appropriately anonymized is also crucial for safeguarding data confidentiality and privacy. To prevent mistakes and false conclusions, researchers must also confirm the precision and dependability of AI-generated outputs. Furthermore, any biases in AI systems need to be considered because they could compromise the validity and fairness of research findings. Additionally, transparency is crucial, necessitating that researchers reveal the degree to which AI techniques were employed in the study. Even with AI, researchers are still responsible for the integrity of their work and must refrain from unethical actions like manipulating or fabricating data. For results to be reliable and repeatable, AI methods must be properly

documented. Lastly, in order to guarantee that the application of AI advances knowledge while protecting participant rights and welfare, researchers must adhere to established ethical norms and regulatory restrictions.

Conclusion

The study concluded that the implementation of the Comic-Based Realistic Mathematics Approach (RMA) among Grade 9 students at Wenceslao Trinidad Memorial National High School was highly effective in improving students' critical thinking skills in mathematics. Students demonstrated excellent performance in analysis, logical reasoning, and application of mathematical concepts, although some higher-order thinking skills still require further enhancement. The findings also revealed a significant relationship between the implementation of Comic-Based RMA and students' critical thinking skills, indicating that the approach contributes positively to the development of students' analytical and problem-solving abilities. These results highlight the importance of integrating visual, contextualized, and learner-centered instructional strategies to strengthen students' critical thinking and meaningful learning in mathematics.

Recommendations

Based on the findings of the study, teachers are encouraged to continuously integrate Comic-Based Realistic Mathematics Approach (RMA) in mathematics instruction to make learning more engaging, meaningful, and relevant to students' real-life experiences. Teachers may also provide more activities that develop higher-order thinking skills such as reasoning, analysis, evaluation, and problem-solving through guided discussions and contextualized tasks. Schools are encouraged to support active and interactive learning strategies that increase student participation and critical thinking development. Furthermore, school administrators may provide professional development programs and continuous instructional support to help teachers effectively implement Comic-Based RMA and improve mathematics instruction.

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