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Unlocking Mathematical Minds: Exploring Creative Thinking, Critical Thinking, and Problem-Solving Skills of Generation Z Learners

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Abstract

This study investigates the level of creative thinking, critical thinking, and problem-solving skills of Generation Z learners in Mathematics, focusing on 77 Grade 10 students from five public schools in the district of Tangalan, Aklan, Philippines. Using a quantitative correlational research design, the study employed cluster sampling to select one section per school, and G*Power was used to determine the appropriate sample size. Three test instruments were utilized to assess the levels of creative thinking, critical thinking, and problem-solving skills. The Mathematical Creative Thinking Test included four items: Items 1 and 2 were adopted from Paniagua (2022), Item 3 was based on Ariawan et al. (2024), and Item 4 from Fauzi et al. (2019). Descriptive statistics such as mean, standard deviation, and frequency were used to analyze students' performance levels. Pearson's r and multiple regression analyses were employed to explore relationships and predictive effects. The findings revealed that most learners demonstrated moderate creative thinking and problem-solving skills, while critical thinking was predominantly at Level 1 (Beginning). Correlation and regression analyses indicated no significant relationships or predictive effects among the three variables. These findings suggest that creative thinking, critical thinking, and problem-solving are distinct cognitive skills that must be developed independently. While this study confirms that Gen Z learners exhibit varying proficiency levels in these skills, its broader implication lies in understanding how these abilities develop independently rather than in a sequential or interdependent manner.

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Introduction

In the rapidly evolving landscape of the 21st century, developing essential skills such as *creative thinking skills*, *critical thinking skills*, and *problem solving* is crucial, particularly in education. Mathematics, as a fundamental subject, is designed to train students to think logically, analytically, systematically, critically, and creatively (Yayuk et al., 2020). Despite its significance, Filipino students continue to struggle in mathematics, as reflected in international assessments. In the 2018 Programme for International Student Assessment (PISA), the Philippines scored 353 in Mathematical Literacy, significantly below the global average (PISA 2022; Factsheets Philippines, 2023). In PISA 2022, the Philippines ranked 61st out of 64 countries, placing among the bottom four in creative thinking, with performance lower than expected, even after accounting for reading skills (PISA 2022; Factsheets Philippines, 2023). Similarly, in the 2019 Trends in International Mathematics and Science Study (TIMSS), the Philippines recorded the lowest scores among 58 participating countries, with 297 in Mathematics and 249 in Science (Magas, 2023).Likewise, in the context of the schools where this study was conducted, the same observation was made—learners showed low levels of performance in Mathematics, particularly in *creative thinking skills*, critical *thinking skills*, and *problem solving* skills, reflecting the national trend.

In the Philippines, the twin goals of mathematics education are critical thinking and problem solving skills (DepEd, 2016). Critical thinking is the ability to think clearly and rationally about what to do or what to believe. It includes the ability to engage in reflective and independent thinking (Kim, 2019). On the other hand, problem solving encapsulates a complex and logical cognitive process, leading to a satisfactory explanation for resolving problems. This is especially significant in mathematics (Gurat, 2018). Creative thinking is also essential in solving mathematical problems or generating new ideas (Hadar & Tirosh, 2019). This process involves identifying the latest regular properties of objects and their transformation (Perry & Karpova, 2017). Developing these skills is vital for enhancing students' mathematical learning and overall cognitive growth. However, research suggests that Generation Z learners, typically aged 12–27 years, struggle with problem solving and often fail to analyze situations critically, contextualize them, and make well-informed decisions (Coombs, 2018).

Several studies have explored the relationships among higher-order thinking skills, learning achievement, and educational outcomes. Anwar et al. (2012) found significant correlations among creative thinking, critical thinking, and problem solving skills. Similarly, a study conducted by Susanti and Hartono (2019) revealed that the average problem solving and mathematical critical thinking skills of junior high school students were in the medium category, with critical thinking skills being slightly higher than problem solving skills. Additionally, the relationship between these skills was classified as moderate. Meanwhile, Siburian et al. (2019) found a strong correlation between critical thinking and creative thinking in improving students' cognitive learning outcomes, suggesting that enhancing one skill can simultaneously strengthen the other.

Given the persistent challenges in mathematics education, particularly in fostering creative thinking, critical thinking, and problem-solving skills among students, this study sought to examine the current state of these skills among Generation Z learners. With the declining performance of Filipino students in international assessments and the need to improve the quality of mathematics instruction, this research aims to provide valuable insights

that can inform curriculum development and instructional strategies in secondary schools.

Theoretical and Conceptual Framework

The study is framed within Bloom's Revised Taxonomy (Krathwohl, 2002), which categorizes cognitive learning into hierarchical levels from basic remembering to higher-order skills like analyzing and creating. This framework guides the exploration of Generation Z learners' cognitive development, emphasizing creative thinking, critical thinking, and problem-solving. Additionally, Jean Piaget's Cognitive Constructivist Theory (1964) informs the study, highlighting active knowledge construction through engagement and experience. This approach underscores learners' development of abstract reasoning and logical thinking during adolescence, crucial for fostering these skills in mathematics education.

The conceptual framework visually depicted in Figure 1 illustrates how creative thinking, critical thinking, and problem-solving skills interrelate within the study's quantitative research design.

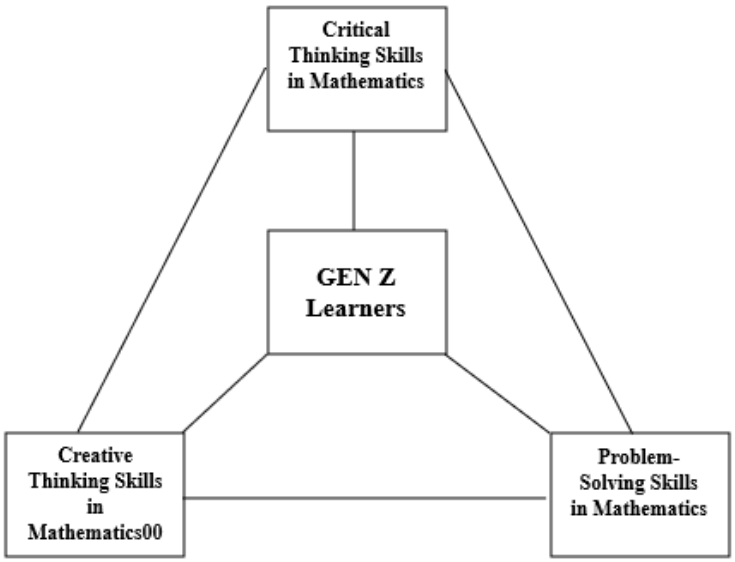

Figure 1. Conceptual Paradigm of the Study

Research Questions

This study aimed to assess the *creative thinking*, *critical thinking*, and *problem solving* skills of Gen Z learners in Mathematics. Specifically, the study sought to answer the following questions:

1. What are the levels of *creative thinking* skills among Gen Z learners in Mathematics, in general and by school?
2. What are the levels of *critical thinking* skills of Gen Z learners in Mathematics, in general and by school?
3. What are the levels of *problem solving* skills of Gen Z learners in Mathematics, in general and by school?
4. Are there significant relationships among *creative thinking* skills, *critical thinking* skills, and *problem solving* skills?

5. Are the following skills significant predictors of the latter, namely:
   a. *Creative thinking* skills and *critical thinking* skills to *problem solving* skills
   b. *Critical thinking* skills and *problem solving* skills to *creative thinking* skills
   c. *Creative thinking* and *problem solving* skills to *critical thinking* skills

Hypotheses

1. There are no significant relationships among creative thinking skills, critical thinking skills, and problem solving skills among Gen Z learners in Mathematics.
2. Creative thinking skills, critical thinking skills, and problem solving skills are not significant predictors of each other among Gen Z learners in Mathematics.

Method

Research Design

This study utilized a descriptive correlational research design. Quantitative research methods focus on measurements that are objective, with statistical analysis or numerical data collecting. Data are gathered through different methods such as polls and questionnaires (Creswell, 2014). According to Devi et al. (2022), a correlational research design investigates relationships between variables without the researcher controlling or manipulating any of them. A correlation reflected the strength and/or direction of the relationship between two or more variables. This method was best suited for this study to effectively examine the relationship among creative thinking, critical thinking, and problem solving skills of Gen Z learners in Mathematics.

Locale and Respondents of the Study

The study was conducted in five public schools in the Province of Aklan in the Philippines—three Integrated Schools and two National High Schools. The schools varied in grade offerings, with two providing complete K–12 education and one offering only up to Junior High School. The schools offered Junior and Senior High School programs. A total of 77 Grade 10 students were selected through cluster sampling from 420 enrollees across these schools for the 2024–2025 school year (see Table 1). The sample size was determined using G*Power software at a 95% confidence level and moderate effect size. Grade 10 learners were chosen because they are at a critical stage in developing essential mathematical, creative, critical thinking, and problem-solving skills.

Table 1. Distribution of Respondents by Secondary School in Aklan, Philippines

School	Frequency (n)	Percentage (%)
A	6	8%
B	9	12%
C	14	18%
D	19	25%
E	29	37%
Total	77	100%

Data Gathering Instruments

In the study, the researcher utilized three sets of tests to assess the creative thinking, critical thinking, and problem solving skills of Gen Z learners in Mathematics. The Mathematical Creative Thinking Test consisted of Items 1 and 2, adopted from Paniagua (2022), Item 3, designed based on the research of Ariawan et al. (2024), and Item 4, based on the research of Fauzi et al. (2019). Both the Mathematical Critical Thinking Test and the Mathematical Problem Solving Test were also adopted from Paniagua (2022). The test questionnaire was validated by three experts in the field of Mathematics to ensure its reliability. The *Mathematical Creativity Skills Test* consisted of four items designed to measure learners' ability to generate novel and original ideas while thinking outside the box in mathematical problem solving. The scoring rubric evaluated three dimensions: fluency, flexibility, and originality. The *Mathematical Critical Thinking Skills Test* comprised 10 multiple-choice questions aimed at assessing learners' ability to reason logically, analyze information, and make sound judgments when solving mathematical problems. Lastly, the *Mathematical Problem Solving Skills Test* included five math problem sets that required learners to analyze problems, apply appropriate mathematical concepts, and demonstrate systematic approaches in arriving at solutions.

Data Analysis

The study utilized descriptive statistics (mean, frequency, percentage), Pearson's correlation coefficient, and multiple regression analysis, all conducted using IBM SPSS Statistics Version 27 for accuracy. Skill levels were categorized using mean scores: Creative Thinking: High (25–36), Moderate (13–24.99), Low (0–12.99) – based on Paniagua (2022). Critical Thinking: Level 4 (8–10), Level 3 (6–7.99), Level 2 (4–5.99), Level 1 (0–3.99). Problem Solving: High (40–50), Moderate (20–39.99), Low (0–19.99).

The Shapiro-Wilk test confirmed normal data distribution, justifying the use of Pearson's correlation to analyze relationships among the three skills. Correlation strength was interpreted using Turla et al. (2024): Very High (0.80–1.0), High (0.60–0.79), Moderate (0.40–0.59), Low (0.20–0.39), Very Low (0–0.19). Multiple regression analysis tested whether one skill could predict another. A p-value < 0.05 indicated a significant predictive relationship, while $p > 0.05$ meant no sufficient evidence of prediction (Frost, 2025).

Results and Discussion

Levels of Creative Thinking Skills

The results show that the Gen Z learners' creative thinking skills in Mathematics are generally at a moderate level, with an overall mean score of 19.94 (SD = 3.67). This means most students are able to generate ideas and explore various solutions, but still need improvement (see Table 2). Among the five schools, School B had the highest mean score of 24.22 (SD = 2.91), suggesting stronger and more consistent creative thinking skills. In contrast, School A had the lowest mean of 15.00 (SD = 7.04), indicating weaker and more varied performance. Schools C (M = 18.00, SD = 2.77), D (M = 19.84, SD = 5.27), and E (M = 22.62, SD = 5.31) also showed moderate creative thinking levels, but with different consistency among learners. However, the differences in their standard

deviations suggest variations in how consistently learners within each school perform in creative thinking tasks. These findings highlight the need for targeted interventions to support schools with lower mean scores while sustaining and further enhancing the creative thinking skills of learners in schools with higher scores.

These results support previous studies on students' creative thinking in mathematics. Junaedi et al. (2021) found that 69% of students had medium-level creative thinking, while 14% were high and 17% low. They also noted that students with high creativity often had strong math skills and joined competitions, showing a link between mathematical ability and creative thinking.

Table 2. Levels of Creative Thinking Skills of Gen Z learners in Mathematics

School	Mean	SD	Descriptive Rating
A	15.00	7.04	Moderate Creative Thinking Ability
B	24.22	2.91	Moderate Creative Thinking Ability
C	18.00	2.77	Moderate Creative Thinking Ability
D	19.84	5.27	Moderate Creative Thinking Ability
E	22.62	5.31	Moderate Creative Thinking Ability
Overall Mean	19.94	3.67	Moderate Creative Thinking Ability

Note: Description is based on the following scale. 25.00 - 36.00 (High Creative Thinking Ability), 13.00 - 24.99 (Moderate Creative Thinking Ability), 1.00 - 12.99 (Low Creative Thinking Ability).

Levels of Critical Thinking Skills

The results show that Gen Z learners' critical thinking skills in Mathematics are mostly at Level 1 (Beginning), with an overall mean of 3.77 (see Table 3). This means that many students struggle to understand and analyze math problems and have difficulty making clear, well-supported conclusions. Schools A (M = 2.80, SD = 1.47), C (M = 3.57, SD = 1.50), and E (M = 3.76, SD = 1.53) all fall under Level 1, showing that learners in these schools have weak critical thinking skills. School A had the lowest average, meaning students there face the most difficulty. The high standard deviations suggest that while some learners perform slightly better, many are still behind. Schools B (M = 4.56, SD = 1.67) and D (M = 4.16, SD = 1.34) reached Level 2 (Developing). Students in these schools are starting to improve their thinking and analysis skills, but they still need more support to deepen their reasoning. No school reached higher levels of critical thinking, which means most students need help in building these essential skills. This calls for better strategies in teaching critical thinking, such as practicing analysis, reflection, and reasoning in math lessons.

Several studies support the findings of this research. Saylo (2016) reported that learners' critical thinking skills were only fairly developed, presenting a serious challenge for educators. This matches the current study's results, where most learners remain at the beginning level. On the other hand, Alcantara and Basca (2017) found that students had generally above-average critical thinking skills, yet still recommended retraining to improve further. Glaze (2018) emphasized the need for both knowledge and strong thinking skills for success, while Strauss (2016) highlighted that developing critical thinking must be a priority in education. These studies all point to the

importance of continuously improving learners' critical thinking through targeted support and instructional strategies.

Table 3. Levels of Critical Thinking Skills of Gen Z learners in Mathematics

School	Mean	SD	Descriptive Rating
A	2.80	1.47	Level 1 (Beginning)
B	4.56	1.67	Level 2 (Developing)
C	3.57	1.50	Level 1 (Beginning)
D	4.16	1.34	Level 2 (Developing)
E	3.76	1.53	Level 1 (Beginning)
Overall Mean	3.77	0.67	Level 1

Note: Description is based on the following scale. 8.00 - 10.00 (Level 4-Exemplary), 6.00 - 7.99 (Level 3 – Proficient), 4.00 - 5.99 (Level 2-Developing), 0.00 - 3.99 (Level 1-Beginning).

Levels of Problem Solving Skills of Gen Z Learners in Mathematics

The results reveal that Gen Z learners' problem solving skills in Mathematics are generally moderate, with an overall mean of 23.33 and a standard deviation (SD) of 8.16 (see Table 4). Among the five schools, School D had the highest mean score (M = 37.21, SD = 4.16), showing stronger problem solving skills. School B (M = 23.89, SD = 9.39) and School A (M = 20.17, SD = 1.94) also showed moderate abilities. In contrast, School C (M = 17.50, SD = 5.49) and School E (M = 17.90, SD = 7.20) fell under the low problem solving skills category. The wide standard deviations in Schools B and E indicate varied abilities among learners, suggesting that while some students perform adequately, others significantly lag behind. These findings highlight the need to enhance teaching strategies, especially in lower-performing schools.

Table 4. Levels of Problem Solving Skills of Gen Z learners in Mathematics

School	Mean	SD	Descriptive Rating
A	20.17	1.94	Moderate Problem Solving Skills
B	23.89	9.39	Moderate Problem Solving Skills
C	17.50	5.49	Low Problem Solving Skills
D	37.21	4.16	Moderate Problem Solving Skills
E	17.90	7.20	Low Problem Solving Skills
Overall Mean	23.22	8.16	Level 1

Note: Description is based on the following scale. 40.00 - 50.00(High Problem Solving Skills),20-00-39.99 (Moderate Problem Solving Skills), 0.00-19.99 (Low Problem Solving Skills).

The findings of this study are consistent with previous research. Cambaya et al. (2022) and Hijada and Dela Cruz (2022) both found that many learners showed low or non-proficient levels in problem solving, especially when applying math to real-life situations. Malasari et al. (2017) stressed the importance of mathematical literacy in solving real-world problems, while Sumitha and Rexlin (2016) noted that many students perform at an average level but struggle with unfamiliar or complex tasks. Similarly, Canlas et al. (2022) observed that students' problem

solving strategies are often inconsistent and underdeveloped. These studies all support the current study's conclusion that targeted interventions are needed to improve the problem solving skills of learners.

Correlation Analysis among Creative Thinking, Critical Thinking, and Problem Solving Skills of Gen Z learners in Mathematics

The correlation analysis revealed weak and statistically insignificant relationships among creative thinking, critical thinking, and problem-solving skills (see Table 5). None of the skills significantly predicted or correlated with one another, suggesting that these cognitive processes function independently. Creative thinking is driven by divergent thinking, critical thinking by convergent reasoning, and problem solving combines both but focuses on goal-oriented execution.

These findings align with previous studies (e.g., Bacangallo et al., 2022; Turla et al., 2024), which found no meaningful connections between these skills. As a result, each skill must be developed through specific, targeted strategies, rather than a one-size-fits-all approach. Teachers should use distinct assessments and teaching methods to nurture each skill separately and recognize their unique contributions to 21st-century learning and real-world application.

Table 5. Correlation among Creative Thinking, Critical Thinking, and Problem Solving Skills in Mathematics

		Creative Thinking	Critical Thinking	Problem Solving
Creative Thinking	Pearson Correlation	1	-	-
	Sig. (2-tailed)			
Critical Thinking	Pearson Correlation	.172	1	-
	Sig. (2-tailed)	.135^{ns}		
Problem Solving	Pearson Correlation	.042	.152	1
	Sig. (2-tailed)	.715^{ns}	.186^{ns}	

Legend: ***** *Significant correlation at $p < 0.05$*

ns *Not significant correlation at $p > 0.05$*

Predictive Analysis

Creative Thinking Skills and Critical Thinking Skills as Predictors of Problem Solving Skills

The results of the regression analysis show that neither creative thinking (B = 0.031, p = 0.888) nor critical thinking (B = 1.012, p = 0.203) significantly predict students' problem-solving skills (see Table 6). This means that even if a learner is good at creative or critical thinking, it doesn't automatically mean they are good at solving

math problems. Other factors like prior knowledge in math, motivation, reasoning, and thinking about one's own thinking (metacognition) might have a stronger effect on problem-solving. It's also possible that the connection between these skills isn't straightforward and may involve other variables.

Table 6. Regression Coefficients for Problem Solving Skills

Coefficients	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig.
(Constant)	18.932		3.674	0.000
Creative Thinking	0.031	0.16	0.141	0.888
Critical Thinking	1.012	0.150	1.283	0.203

a. *Predictors:(Constant), Creative Thinking Skills, Critical Thinking Skills*

b. *Dependent Variable: Problem Solving Skills*

These findings show that being good in one skill doesn't guarantee strength in another. Therefore, teachers should focus on developing each skill—creative thinking, critical thinking, and problem-solving—separately using teaching strategies designed for each one. This way, learners can grow in all areas and become more capable in math.

Critical Thinking Skills and Problem Solving Skills as Predictors of Creative Thinking Skills

Based on the analysis, critical thinking skills had a weak positive effect on creative thinking with a coefficient of B = 0.607, but it was not statistically significant ($p = 0.141 > 0.05$). Similarly, problem solving skills had a very small effect (B = 0.009) and was also not significant ($p = 0.888 > 0.05$). This means that neither skill can strongly predict students' creative thinking ability in this study (see Table 7).

Table 7. Regression Coefficients for Creative Thinking Skills

Coefficients	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig.
(Constant)	18.151		8.751	0.000
Critical Thinking	0.607	0.169	1.462	0.141
Problem Solving	0.009	0.016	0.148	0.888

a. *Predictors:(Constant), Problem Solving, Critical Thinking Skills*

b. *Dependent Variable: Creative Thinking Skills*

This suggests that creative thinking works differently from critical thinking or problem solving. It involves not only logic and evaluation, but also the ability to see problems in different ways and think outside the box. For example, creative thinking includes activities like brainstorming and coming up with original ideas that may not follow a step-by-step solution.

Creative Thinking and Problem Solving Skills as Predictors of Critical Thinking Skills

The regression analysis shows that problem solving skills (B = 0.022, p = 0.203) and creative thinking skills (B = 0.046, p = 0.148) both have weak positive relationships with critical thinking skills, but neither is statistically significant, as their p-values are greater than the 0.05 threshold (see Table 8). Specifically, the p-value for problem solving skills is 0.203, and for creative thinking skills, it is 0.148. Since both p-values exceed 0.05, thus problem solving skills and creative thinking skills are not significant predictors of critical thinking skills.

Table 8. Regression Coefficients for Creative Thinking Skills

Coefficients	Unstandardized Coefficients (B)	Standardized Coefficients (Beta)	t-value	Sig.
(Constant)	2.383		3.102	0.003
Problem Solving	0.022	0.145	1.283	0.203
Creative Thinking	0.046	0.166	1.462	0.148

a. *Predictors:(Constant), Problem Solving, Creative Thinking Skills*

b. *Dependent Variable: Critical Thinking Skills*

Fatmawati et al. (2019) explained that creative thinking and critical thinking serve different purposes, with the latter being more convergent. While creative thinking seeks to produce new ideas, critical thinking evaluates the validity or worth of existing ones. Creative thinking often challenges established principles, whereas critical thinking applies them. Despite their differences, these two cognitive processes can be seen as complementary rather than identical.

Conclusion

In the 21st century, students must develop essential skills such as creative thinking, critical thinking, and problem solving to navigate complex challenges, particularly in Mathematics. While this study confirms that Gen Z learners exhibit varying proficiency levels in these skills, its broader implication lies in understanding how these abilities develop independently rather than in a sequential or interdependent manner.

Specifically, the moderate level of creative thinking among Gen Z learners in Mathematics may be due to limited opportunities for exploration, a structured curriculum, and a learning environment that does not fully encourage creativity. While they can generate ideas and consider different approaches, their creative potential is not fully developed. Providing more activities that promote originality and flexibility can help strengthen their creative thinking skills.

The low critical thinking skills of Gen Z learners in Mathematics may stem from a reliance on rote learning, limited exposure to higher-order thinking tasks, and a curriculum that emphasizes procedural knowledge over deep conceptual understanding. Additionally, minimal opportunities for analysis, evaluation, and logical reasoning may hinder their ability to interpret and explain mathematical concepts effectively. Strengthening

critical thinking instruction through inquiry-based learning, guided questioning, and analytical discussions could help enhance their reasoning skills and overall cognitive development.

The moderate level of problem solving skills among Gen Z learners in Mathematics may be due to a basic understanding of problem solving strategies but a lack of refinement in planning, execution, and evaluation. Limited practice in applying different approaches and reflecting on solutions may also contribute to this level of proficiency. Providing more opportunities for structured problem solving tasks and encouraging logical reasoning can help enhance their skills and confidence in solving mathematical problems.

However, this study goes beyond identifying skill levels by establishing that creative thinking, critical thinking, and problem solving are distinct cognitive processes, rather than inherently linked abilities. These skills function independently, without significant interdependence or direct influence on one another. This challenges the assumption that improving one skill automatically enhances the others, emphasizing the need for targeted instructional approaches that develop each skill separately to maximize student learning and cognitive growth. The absence of significant predictive relationships among these skills reinforces the need for instructional strategies that focus on cultivating each skill independently, rather than relying on a generalized approach.

Recommendations

Learners may benefit from self-reflection to identify their strengths and weaknesses, enabling them to enhance 21st-century skills such as creative thinking, critical thinking, and problem solving, thereby preparing them for future academic and career challenges.

Teachers may consider adapting their teaching strategies to explicitly develop creative thinking, critical thinking, and problem solving skills in Mathematics. This could involve creating activities that target each skill separately: fostering creative thinking through diverse approaches and idea generation, promoting critical thinking via exercises that encourage logical reasoning and reflection, and strengthening problem solving abilities with tasks that guide students through planning, execution, and evaluation of solutions.

The Department of Education (DepEd), along with policymakers, school administrators, and curriculum experts in the Philippines, may use the findings of this study to improve the development of creative thinking, critical thinking, and problem-solving skills among learners. This can be done by revising teaching strategies, updating learning materials, and offering professional development for teachers. The results can also help guide curriculum improvements to meet 21st-century learning needs. In addition, special programs and support may be provided to schools where learners showed low levels of these skills, ensuring that targeted interventions are in place to help close the gaps and enhance overall student performance.

Other researchers may build upon this study by further exploring the development and interconnections between creative thinking, critical thinking, and problem-solving skills across diverse educational settings. Subsequent research could investigate the effectiveness of specific interventions or teaching approaches in enhancing these

skills and explore their long-term impact on students' academic achievement and overall success. Additionally, other researchers may increase the number of respondents as well as the scope of the test materials to provide a broader and more comprehensive understanding of these skills.

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