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PROMOTING MATHEMATICAL ACHIEVEMENT THROUGH CREATIVE THINKING AND STRUCTURED ACTIVITY EXPOSURE IN HIGH SCHOOL EDUCATION

Aries Albert A. Abellana[1],
Merce Joy L. Faburada[2],
Vernie C. Ruiz[3],
Alfonso A. Lenizo[4],
Rylle Lhenz S. Perez[5i]
[1]Pardo National High School,
Cebu City, Philippines
[2]Cebu Children of Hope School Foundation, Inc.,
Cebu City, Philippines
[3]Pagsabungan National High School,
Mandaue City, Cebu, Philippines
[4,5]Alaska National High School,
Cebu City, Philippines

Abstract:
This research explored the relationship between creative thinking skills, exposure to creative activities, and mathematics achievement among 250 Grade seven students in a public high school in Cebu City, Philippines, using a descriptive correlational design. The respondents were identified using simple random sampling. Data were collected using researcher-made instruments on the Creative Thinking Skills and Creative Thinking Activities Exposure Scale, which underwent pilot testing, while Mathematics Achievement was measured using their Fourth Quarter grades. Data were analyzed using descriptive and inferential statistics. Results showed respondents' moderate creative thinking skills, with high exposure to activities promoting creative thinking skills. On the one hand, the respondents' mathematical achievement was satisfactory. Moreover, there was a significant moderate positive relationship between the respondents' creative thinking skills and exposure to creative thinking activities, while no significant relationship between creative thinking skills and mathematics achievement. Similarly, no significant relationship between exposure to creative thinking activities and mathematics achievement was found. Recommendations were made to include creative thinking activities in the curriculum, enrichment programs for students, and teacher training in innovative methodologies.

[i] Correspondence: email ryllelhenz1992@gmail.com

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1. Introduction

Creative thinking is important for learning mathematics; it is the base that underlies innovation and solving problems (Yayuk & As'ari, 2020). In engaging in creative thinking within mathematics, the student will find patterns more quickly and see problems from different perspectives to create original solutions (Rahayuningsih *et al.*, 2021). This approach makes the learner understand mathematics deeply because it encourages an open, analytical mindset to explore novel methods (Irvine, 2020). Creativity in mathematics is very crucial for the success of students, both in the academic world and the real world, as society places more emphasis on creativity and innovation.

However, the performance of the students in the Philippines on the Programme for International Student Assessment (PISA) shows that the country needs to improve its score on the creative thinking assessment (Organization of Economic Cooperation and Development, 2024). This is problematic because, if there is a lack of performance, it reflects significantly on the mathematics curriculum at the basic education level. The PISA found a considerable gap between Filipino students and others worldwide: the current teaching methodologies may not provide for developing this capacity. Thus, this shortfall bars the country from improving its education system and preparing students to face an increasingly fast-moving, innovation-driven global economy.

This is even more reflected in the Southeast Asia Primary Learning Metrics 2019 report, which manifests that Filipino students perform much worse in reading, writing, and mathematics than their Southeast Asian peers. Only 10 percent of Grade 5 students in the Philippines have reached adequate proficiency levels in reading based on end-of-primary standards, with a similar pattern observed in mathematics. This stark difference alone already constitutes an imperative that calls for urgent reform in education to ensure the inculcation of creative and critical thinking that should characterize the minds of Filipino students.

Similar issues have been noted in Philippine public high schools, particularly with the Grade seven students. Teachers and school administrators have noticed that the students are rarely able to carry out or even try activities that require creativity, such as solving open-ended problems, conducting mathematical investigations, or undertaking project-based learning. This indicates some inadequacies in the curriculum and method that may not even permit the learners to realize and utilize creativity in math.

In fact, despite all these concerns, research about the creative thinking skills of students in high school mathematics education is very scarce. Most studies have primarily concentrated on students' performance on standardized tests or fundamental mathematical skills, as evidenced by the Trends in Mathematics and Science Survey (TIMSS) conducted by Sanchez and Ponce (2020) and Wardat *et al.* (2022), as well as PISA studies by Orbeta *et al.* (2021) and Acido and Caballes (2024), and National Achievement

Tests (NAT) researched by Alinsunurin (2021) and Naungayan (2022). This research gap emphasizes the need to investigate students' creative thinking skills and their exposure to curriculum-wide activities designed to develop these skills.

The mathematics education problems are also manifested in the Cebu City National Achievement Test (NAT) performance taken from the school year 2023 - 2024, where the Mean Percentage Score (MPS) was only 53.91, which is very much below compared to the Department of Education (DepEd) of Cebu City's target MPS of 75. This shows clearly that educational reform focusing on imaginative and analytical thinking in math education is much needed. In view of such weak performance, there is a need to examine how the creative thinking abilities of the students and access to math-boosting activities shape their learning. A study of this issue can be helpful in determining how new learning approaches can bridge this gap and enhance the mathematical capabilities of the students.

It is in this context that this research assesses students' creative thinking skills, exposure to creative thinking activities, and mathematics achievement. The findings of this study are expected to significantly impact the planning and implementation of improved mathematics education in the country. Teachers and administrators can develop targeted interventions to enhance creative thinking skills by analyzing students' strengths and weaknesses and their exposure to relevant activities. Thus, this study aimed to ascertain the influence of creative thinking and activity exposure on the mathematics performance of Grade seven students at a public school for the school year 2024-2025.

Specifically, it sought to answer the following objectives:

1) To determine the extent of the respondents' creative thinking skills.
2) To assess the level of respondents' exposure to activities promoting creative thinking skills.
3) To test the relationship between the respondents' creative thinking skills and exposure to activities promoting creative thinking skills.
4) To test the relationship between the respondents' creative thinking skills and their mathematics achievement.
5) To test the respondents' exposure to activities promoting creative thinking skills and their mathematics achievement.

2. Literature Review

Three fundamental educational theories that are pertinent to high school mathematics instruction form the basis of this study's theoretical framework. According to Torrance's Theory of Creative Thinking (1969), students can develop their creativity through fluency, flexibility, originality, and elaboration. It suggests that math teachers can systematically improve these skills by assigning creative problem-solving exercises. This is supported by Guilford's Theory of Divergent Thinking (1967), which emphasizes creativity as a quantifiable aspect of intelligence that is characterized by the capacity to

produce multiple solutions—a crucial ability when addressing open-ended or real-world mathematical problems. In the meantime, Vygotsky's Constructivist Learning Theory (1978) emphasizes the value of social interaction, teacher scaffolding, and active participation. These elements are essential for assisting students in understanding abstract mathematical concepts through peer collaboration and guided discovery.

These theories lend support to a teaching strategy that fosters deeper mathematical understanding by moving beyond rote memorization. Students are more likely to remain interested, think critically, and apply what they have learned to real-world situations when creativity is incorporated into structured activities. This framework supports cutting-edge methods of teaching math that combine creativity and structure to improve engagement and achievement.

Torrance's Theory of Creative Thinking also serves as an anchor for this study. According to Torrance (1969), creative thinking is the ability to identify knowledge gaps, suggest solutions to issues, generate original notions, reorganize preexisting ideas uniquely, and infer new connections between seemingly unrelated ideas. Fluency, flexibility, originality, and elaboration are all constituents of creative thinking, so that students can approach the issues from different angles and develop a variety of possible answers. According to this theory, the creative potential in educational contexts is significant for intellectual growth and creativity.

The Theory of Divergent Thinking proposed by J.P. Guilford (1967) is closely tied to creative thinking, particularly in educational contexts such as high school students' development of mathematical skills. Guilford distinguished between divergent thinking, which promotes the creation of several answers to open-ended situations, and convergent thinking, which is concerned with finding a single, accurate solution. In this idea, divergent thinking is a fundamental component of creativity as it entails examining many options, addressing challenges from new angles, and thinking flexibly. This idea is consistent with creative problem-solving techniques, particularly in mathematics, where students are encouraged to investigate other approaches and methodologies in addition to determining the correct answer.

High school students can develop their creative thinking abilities when participating in activities that foster mathematics knowledge, mainly when they apply divergent thinking. Innovative approaches to problem-solving, hypothesis testing, and investigation are all mathematical activities that can encourage students' creative thinking. Students can work on projects that require them to think beyond the box, rather than just memorizing facts by heart or using previously acquired formulas. This enables students to hone the abilities at the core of Guilford's divergent thinking model—generating alternative answers, assessing various approaches, and applying abstract thinking. Giving pupils complex, real-world problems, for example, where different approaches can result in other solutions, can encourage mathematical proficiency and creative thinking.

Constructivist learning theory, developed by Lev Vygotsky in 1978, emphasizes the value of social interaction, cultural context, and active learning. The "Zone of

Proximal Development" (ZPD), where students take on problems just slightly above their existing capabilities with guidance, is at the heart of this idea. It promotes collaborative knowledge building. This student-centered method is essential for fostering creative thinking in mathematics since it encourages critical thinking through inquiry-based learning, problem-solving, and discovery. Students develop their mathematical creativity and critical thinking abilities by participating in activities such as group problem-solving, practical tasks, and real-life applications within their ZPD.

Several theoretical orientations and empirical studies underpin the facilitation of mathematical attainment with creative out-of-context experience and unit-structured activity in second-level education. Prospective elementary mathematics teachers have a well-founded knowledge of the theoretical basis of Realistic Mathematics Education (RME), but have difficulty applying it effectively, such as distinguishing RME from other approaches, and developing context-embedded problems (Rezan & Yilmaz, 2020). Based on this, Harefa *et al.* (2024) stressed that learning at school means not only that students improve their mathematical knowledge when they learn in context, collaborate in projects, and engage in reflective discussions, but also that the students develop as human beings. These results underscore the importance of programs that engage students in activities that enhance creative and critical thinking, as well as enrich their understanding of mathematical ideas inside and beyond the classroom.

As part of the creative process, structured tasks can help students become inventors by encouraging experimentation, original thought, and a variety of problem-solving techniques (Clements & Sarama, 2021). Future research should examine integrating both strategies within explicit word-problem instruction. Interventions can either build working memory capacity or compensate for working memory limitations. Fuchs *et al.* (2020) state that students with low working memory capacity frequently struggle with mathematical word-problem solving. Better learning outcomes, however, demonstrate that using a problem-posing approach to instruction greatly enhances students' mathematical comprehension abilities when compared to traditional teaching methods (Ammy, 2021).

According to Kholid *et al.* (2021), students have different levels of capability in understanding the many factors in mathematics. The results provide a new contribution to theories of conceptual understanding in mathematics by demonstrating that while moderate and low abilities result in partial or poor conceptual performance, higher mathematical ability leads to better problem-solving accuracy. Although research on the use of visual thinking in mathematics learning is relatively new in comparison to the discipline's long history, visualization is essential for representing abstract mathematical concepts through symbols and diagrams (Presmeg, 2020). Realistic Mathematics Education (RME), as defined by Clements and Sarama **(**2021**)**, is a framework that emphasizes the integration of mathematical learning with real-life contexts, resulting in a deeper comprehension and the development of creative problem-solving skills.

Numerous empirical studies also support the idea that structured problem-solving options foster students' mathematical creativity and achievement. One study, for

instance, discovered that students who participated in structured problem-solving exercises for mathematical creativity (Leipus, 2021) improved their mathematical performance and creativity. According to Ismunandar *et al.* (2020), realistic mathematics teaching strategies successfully enhance students' capacity for original thought. Its effectiveness in improving students' creative and problem-solving skills is demonstrated by the notable increase in students' creative thinking.

It is becoming more widely acknowledged that combining exposure to structured activities with creative thinking can significantly improve mathematical achievement, particularly in high school. The increasing connection between student performance in mathematics, pedagogical frameworks, and creativity is highlighted by recent research and literature. Simamora and Hutauruk (2024), for example, stress that RME is a method that fosters mathematical creativity by relating mathematical instruction to real-life situations. RME encourages the concurrent application of logic and imagination by presenting students with contextual problems and structured learning activities, which improve student outcomes. Furthermore, Ndiung *et al.* (2021) contend that by combining the Treffinger learning model with RME principles, educators should concentrate on enhancing both mathematical learning outcomes and creative thinking. When paired with RME's practical application, the Treffinger model's encouragement of problem-solving and critical thinking greatly improves student performance. According to studies, students who received instruction using this integrated approach outperformed those who received instruction using more conventional methods in mathematics and showed more creativity. In addition to raising academic achievement, this method gives students the tools they need to solve problems and think creatively in the future.

Students' development of mathematical critical thinking skills (MCTS) is negatively impacted by teachers' low MCTS. In contrast to conventional teaching techniques, the study investigates how Realistic Mathematics Education based on Emergent Modeling (RME-EM) can enhance the MCTS of aspiring teachers. Although the study finds no significant interaction between learning methods (RME-EM vs. conventional) and Mathematical Prior Knowledge (MPK) in influencing MCTS achievement, it does demonstrate that RME-EM significantly improves the teaching and learning activities of aspiring teachers. The study concludes that although RME-EM is useful for improving the teaching abilities of aspiring teachers, it has little bearing on how learning strategies and MPK interact to improve MCTS (Afriansyah, 2021). Their use of structured learning activities that encourage both critical and creative thinking reflects the students' dual focus, which aims to foster mathematical achievement by fusing structured and creative approaches. Building on this foundation, Casing and Casing (2024) provided evidence that structured extended learning opportunities centered on teamwork and creative activities enhanced mathematics achievement in their paper "Fostering Students' Mathematics Achievement through After-School Program in the 21st Century." Thus, the notion is that these fully planned interventions have a substantial impact outside of the classroom.

Sachdeva *et al.* (2021) claim that there is a lack of research in mathematics education, specifically concerning students' individual beliefs about their learning process. According to research, students struggle to propose changes that would make their learning process more meaningful, have conflicting beliefs, and infrequently reflect critically on their mathematical learning. Encouragement, however, can help students cultivate a critical mindset toward their education, which improves their capacity to make thoughtful, well-informed decisions regarding their education. To promote a more self-aware and reflective approach to mathematics, the paper suggests that students be taught to think critically about their learning process. It is more important than ever to use structured classroom strategies to encourage critical and reflective thinking. The correlation between prospective middle school math teachers' reflective and critical thinking abilities demonstrates how these abilities differ depending on academic achievement, grade level, and gender. Reflective thinking abilities are moderate, whereas critical thinking abilities are high. These two categories of thinking abilities were found to be positively and significantly correlated, with critical thinking abilities accounting for 24% of the variation in reflective thinking abilities. Furthermore, it was discovered that grade level had an impact on reflective thinking abilities, while gender and academic success had a significant impact on critical thinking abilities (Erdoğan, 2020). To provide a technological perspective, Cano and Lomibao (2023) found that when utilizing phenomenon-based videos in a structured manner, students' problem-solving abilities and self-confidence improve significantly. This data reinforces that even powerful digital learning tools, when combined with structure and creativity, add significant value to student outcomes.

Transitioning from cognitive skills to social learning environments, Carrillo *et al.* (2023) found that group-based, structured learning fosters creativity during a critical developmental period. Their findings show how creativity is not only an individual trait but also a collaborative product of interaction and engagement, reinforcing the thesis's emphasis on structured group tasks as essential for creative learning. Khaled and Alghfeli (2024) demonstrated how clearly defined learning goals and structured self-assessment empower students to take ownership of their progress. By understanding what success looks like, students become more motivated and creatively engaged in problem-solving—highlighting the importance of direction and feedback in creative mathematics education.

Wijaya *et al.* (2021) state that project-based learning enhances the creative design thinking and problem-solving abilities of prospective mathematics teachers. By using dynamic mathematics software like Hawgent and incorporating art into learning materials, the study shows improvements in communication skills, creative thinking, and self-confidence. Additionally, the research highlights the importance of motivation and support for these trainees throughout their project work. This supports the thesis' assertion that not only does creativity matter in math education, but its impact is magnified when delivered through structured and purposeful instructional approaches. Bicer *et al.* (2020) revealed that students who believed in their creative mathematical

abilities performed better when engaged in problem-posing tasks. Their research shows that confidence in creativity—developed through structured opportunities—has a significant influence on mathematical achievement. This complements the thesis by emphasizing the psychological benefits of creativity when embedded within a structured framework.

These various aspects of bridging cognitive psychology, focused learning strategies, and creativity in mathematics education can equip teachers to look for ways to implement changes in classrooms to promote mathematical success in students at higher levels. A structured activity combined with creative reasoning creates a conducive environment for learning that supports students' deeper engagement with sophisticated mathematical models, thereby improving academic results.

3. Materials and Methods

3.1 Research Design

This research used the descriptive-correlational research design defined by Saro *et al.* (2023), best suited for understanding the relationship between creative thinking and exposure to mathematical activities on students' performance. According to Devi *et al.* (2022), this type of design is a research approach that not only presents a detailed description of present conditions but also explores relationships among variables. This methodology enabled the researchers to assess the students' creative thinking levels and their participation in some activities, analyzing how those elements affect performance in mathematics.

3.2 Research Respondents

The respondents of the study were the 250 Grade seven students, representing 20.54% of the 1,217 population, which was determined using Slovin's Formula to ensure reliable representation. These students were currently enrolled for the school year 2024-2025 at a public high school in Cebu City, Philippines. The distribution of the respondents is summarized in Table 1.

Table 1: Distribution of the respondents

Gender	**n**	**%**
Male	95	38.00
Female	155	62.00
Total	**250**	**100.00**

Students who are in the 7th grade were the appropriate respondents to provide information relevant to the study because this grade level is the transition period from primary school to high school. Hence, they are expected to have developed creative thinking abilities because they will be more exposed to more abstract math concepts.

3.3 Data Collection Tools

Researcher-made instruments were used in this study, which underwent validation and reliability tests. To test the validity of the instruments, the researchers consulted three experts in the field and a statistician, whose suggestions and comments were the basis for the subsequent instrument revisions. On the other hand, Cronbach's alpha was used to test the instruments' reliability. The Creative Thinking Skill Questionnaire (CTSQ) was designed to assess students' creative thinking ability in mathematics. It has 15 items designed to measure several aspects of creative thinking, such as problem-solving approaches, self-efficacy for innovative solutions, perception of patterns, and communication of mathematical ideas. Each statement is rated on a Likert scale from "Strongly Agree" (5) to "Strongly Disagree" (1). The Cronbach's alpha value for this instrument was 0.924, indicating a high internal consistency of the statements measuring the construct. On the other hand, the Creative Thinking Activities Exposure Scale (CTAES) gathered data on students' exposure to activities that promote creative thinking in mathematics. This 15-item questionnaire assesses students' engagement in activities encouraging innovative problem-solving, such as solving non-routine math problems, participating in math projects, using math journals, and playing math games. Items were rated on the same Likert scale, ranging from "Strongly Agree" (5) to "Strongly Disagree" (1). The Cronbach's alpha of 0.857 also indicates a high internal reliability.

3.4 Data Collection Process

The researchers sent a transmittal letter to the Cebu City Division Office as the first step in the data collection process, which outlined the study's goals and requested approval to involve Grade seven students as participants. The students were given informed assent forms after obtaining approval from the school division office. Students filled out these forms with complete details about the study, knowing that their participation is optional and their answers will be kept private. An online survey run using Google Forms was the primary tool for gathering data. The respondents received the link to the Google Form via their school email addresses or other school-used communication channels. The respondents were given instructions on finishing the survey and a submission date. To ensure completeness, the researchers tracked the survey replies in real time and contacted those who had yet to reply with reminders. In some cases, the researchers administered the survey on-site at the schools, giving students access to laptops or tablets so they could finish it there. The researchers maintained the respondents' anonymity, and the data gathered were stored appropriately in observance of the Data Privacy Act.

3.5 Data Analysis

The collected data were subjected to the appropriate data treatment and analyses. To evaluate the students' level of creative thinking skills, exposure to activities that foster creative thinking, and their mathematical achievement, weighted mean and standard deviations (SDs) were calculated. The mean provided the numerical measure to describe the variables, and the standard deviation showed the variation or dispersion around the

mean. Pearson's r was also used to test the relationship between respondents' creative thinking skills and their exposure to activities promoting creative thinking skills, creative thinking skills and their mathematics achievement as well as the respondents' exposure to activities promoting creative thinking skills and their mathematics achievement.

Moreover, the study tested the following null hypothesis:

Ho_1: There is no significant relationship between the respondents' creative thinking skills and their exposure to activities promoting creative thinking skills.

Ho_2: There is no significant relationship between the respondents' creative thinking skills and their mathematics achievement.

Ho_3: There is no significant relationship between the respondents' exposure to activities promoting creative thinking skills and their mathematics achievement.

4. Results and Discussion

This section presents the results of the data gathered based on the objectives of the study, which includes the respondents' level of creative thinking skills, exposure to activities promoting creative thinking skills, mathematics achievement, and the results on the test of the relationship between variables investigated.

4.1 Creative Thinking Skills of the Respondents

Table 2 presents respondents' levels of creative thinking skills based on their answers to indicators that reflect creativity in solving problems and math tasks. The weighted mean (WM) and standard deviation (SD) for each indicator will help assess how often and confidently respondents engage in creative thinking when solving math problems. The respondents demonstrated very high creative thinking about math problem-solving, especially when finding patterns in numbers or equations and exploring different ways to approach math problems. The statements "I often search for patterns and relationships in numbers or equations" and "I enjoy exploring different ways to solve a math problem" scored highest with a very high rating. However, several other indicators, such as "I feel confident solving math problems creatively" and "I am good at choosing the most effective method for solving a problem," showed moderate creative thinking. The overall moderate score for creative thinking skills (WM = 3.33) suggests that while some students are highly innovative, a significant number still exhibit only moderate creativity in their mathematical thinking.

Table 2: Level of creative thinking skills of the respondents

S/N	Indicators	WM	SD	Verbal Description
1	I often search for patterns and relationships in numbers or equations	4.54	0.50	Very High
2	I enjoy exploring different ways to solve a math problem.	4.50	0.50	Very High
3	I am open to trying different methods to solve math problems.	3.22	1.48	Moderate
4	I enjoy using creative or unconventional approaches to solve math problems.	3.01	1.43	Moderate
5	I quickly identify the most important part of a math problem.	3.13	1.52	Moderate
6	I feel confident solving math problems creatively.	3.19	1.44	Moderate
7	I'm good at choosing the most effective method for solving a problem.	2.92	1.31	Moderate
8	I keep my math work and notes organized to avoid confusion.	2.90	1.42	Moderate
9	I create clear outlines or strategies before starting a problem.	3.16	1.34	Moderate
10	I regularly review my progress and adjust my methods as needed.	2.94	1.34	Moderate
11	I clearly and concisely express my math ideas in writing and speaking.	3.17	1.44	Moderate
12	I actively listen and consider others' methods when discussing math problems.	3.28	1.52	Moderate
13	I can explain complex math concepts in a way others can understand.	3.34	1.44	Moderate
14	I often come up with creative ways to solve math problems.	3.34	1.50	Moderate
15	I enjoy creating original methods for solving math problems.	3.27	1.61	Moderate
Aggregate Weighted Mean		**3.33**		**Moderate**
Aggregate Standard Deviation			**1.32**	

Legend: 4.21-5.00-Very High; 3.41-4.20-High; 2.61-3.40-Moderate; 1.81-2.60-Low; 1.00-1.80-Very Low

These results lead to the conclusion that creative thinking skills in mathematics are one of the crucial areas of development. A small amount of attention toward developing students' confidence in using unconventional methods and a creative mindset could result in better problem-solving abilities. Teachers can include more creative problem-solving tasks and strategies to encourage these skills further.

The relatively lower scores in some areas of creative thinking indicate a need for interventions that bolster and improve students' creative confidence. Creative thinking is at its best this way; thus, we must continue promoting diverse problem-solving methods and inspiring students to think outside the box while solving math problems.

Rahayuningsih *et al.* (2021) investigated an open-ended problem-solving assessment tool that consisted of open-ended problem-solving tasks and interview guidelines to capture students' cognitive flexibility and fluency. The assessment was designed to measure students' mathematical creativity based on two types: "very creative" and "creative." The findings showed that while "creative" students exhibited flexibility but lacked cognitive fluency, "very creative" students showed both cognitive flexibility and fluency, coming up with multiple solutions and fixing mistakes with ease.

According to the analysis, the assessment instrument successfully gauged students' mathematical creativity in terms of both the end products and the mental operations required to solve problems. Isyrofinnisak *et al.* (2020) investigated the connection between students' mathematical creativity and their thought processes. Four categories of students' thought processes were identified by the study: Concrete Sequential (CS), Abstract Sequential (AS), Concrete Random (CR), and Abstract Random (AR). CS students showed creativity at the flexibility stage, AS students at the fluency stage, CR students at the flexibility stage, and AR students at the novelty stage, according to the findings. The study advises giving students limitless chances to solve problems and urges educators to comprehend students' thought processes to modify teaching strategies and tactics that will best foster mathematical creativity. This highlights how important it is to comprehend and encourage mathematical creativity in a variety of ways. To foster mathematical creativity across a range of student profiles, it advises educators to offer a variety of problem-solving opportunities, emphasizing the value of identifying individual cognitive strengths and thinking styles.

Additionally, teachers can better support the development of both cognitive flexibility and fluency in mathematical tasks by customizing their teaching strategies to fit the cognitive and thinking preferences of their students. Students are guaranteed to develop their ability to approach problems creatively, as well as to refine their ability to generate multiple solutions, adapt to challenges, and improve their overall problem-solving skills, through the integration of open-ended problem-solving tasks and personalized learning strategies. In the end, this method helps students develop their mathematical thinking skills, which makes it possible for them to solve challenging mathematical problems with greater flexibility and creativity.

4.2 Respondents' Exposure to Activities Promoting Creative Thinking Skills

The level of exposure of respondents to activities that induce the development of creative thinking skills is an indicator of their frequency and effectiveness in exposure to tasks meant to inspire the development of innovation, critical thinking, and problem-solving. Academic settings might embrace project-based learning, joint assignments, puzzles, open-ended questions, and experiences for exploration. Exposure outside the classroom may be due to extracurricular activities, such as robotics, math clubs, or creative workshops. High exposure is consistent engagement in varied, stimulating activities that foster originality and innovation, but low exposure means few opportunities. This assessment reflects the gaps and areas that need improvement to cultivate creative thinking abilities.

Table 3: Level of respondents' exposure to activities promoting creative thinking skills

S/N	Indicators	WM	SD	Verbal Description
1	I enjoy solving math problems that allow for creative and unique solutions.	4.56	0.50	Very High
2	I feel confident in tackling math problems that do not have a single correct answer.	3.41	1.11	High
3	I often have math tasks where I can choose my own strategy to find a solution.	3.19	1.48	Moderate
4	I often examine practical applications of mathematical concepts through exploring and investigating real-world applications.	3.41	1.22	High
5	I often work on math projects that connect classroom learning to real-world problems.	3.02	1.48	Moderate
6	I regularly participate in projects where I apply math concepts to develop solutions.	2.46	1.28	Low
7	I feel confident contributing creative ideas to group math projects.	2.24	1.34	Low
8	I regularly write about my problem-solving processes in a math journal.	2.37	1.32	Low
9	I am encouraged to express my thoughts and ideas about math in writing.	2.54	1.23	Low
10	I feel confident using my math journal to reflect on and improve my math understanding.	3.29	1.56	Moderate
11	I frequently solve math puzzles that challenge my logical reasoning and creativity.	4.44	0.50	Very High
12	I feel confident in solving complex mathematical puzzles.	4.50	0.50	Very High
13	I frequently play math games that apply mathematical concepts in a fun way.	4.57	0.50	Very High
14	I regularly engage in math games that challenge my problem-solving skills interactively.	4.56	0.50	Very High
15	I often participate in group math games that encourage collaboration and creative problem-solving.	4.44	0.50	Very High
Aggregate Weighted Mean		**3.53**		**High**
Aggregate Standard Deviation			**1.00**	

Legend: 4.21-5.00-Very High; 3.41-4.20-High; 2.61-3.40-Moderate; 1.81-2.60-Low; 1.00-1.80-Very Low

Table 3 demonstrates the respondents' extent of exposure to engagements that will develop creative thinking skills in mathematics. The listed activities—solving math problems with unique solutions, engaging in real-world applications of mathematics, and playing math games—are excellent ways to promote or improve creative thinking in mathematics. By allowing students to consider several approaches to a problem, these learning activities foster the growth of divergent thinking, which is a crucial aspect of creativity. While games add a fun and challenging element that piques curiosity, real-world applications make math more relevant and interesting. When combined, these strategies aid in converting mathematics from a dry subject into an engaging educational process. By encouraging active participation, adaptable thinking, and real-world

problem-solving, they complement the theoretical framework. This advances the study's objective of raising mathematical proficiency through imaginative, planned experiences. The results show that although students are involved in a considerable number of activities for creative thinking, their exposure to some particular types of activities—like creative group projects and writing in math journals—is less. A more well-rounded approach might focus on increasing these opportunities as part of educational strategies. To enhance students' creative thinking, schools can implement more math projects, increase collaborative group work, and reflective practices like journaling. Students will become more well-rounded in their problem-solving through exploring other creative activities.

Parinya (2020) looks into instructional strategies intended to help mathematically gifted students think more creatively. The participants were talented first-year engineering students at a Thai science and technology university. The study discovered that well-crafted questions, project-based learning, challenge-based learning, problem-solving techniques, and in-depth learning styles all successfully promoted original and perceptive thinking. Outside of the classroom, students were also encouraged to collaborate and participate in discussions using online platforms like Facebook, which further challenged their thinking. Together, these techniques produced a stimulating and encouraging learning atmosphere that met the needs of the students and improved their capacity for original thought.

According to Kozhevnikov and Thornton (2020), students' creative thinking abilities are not being fully developed through reflective practices like group projects and math journaling. Even though students were actively participating in creative math tasks, they discovered a disconnect between the need for reflective and collaborative assignments. Additionally, they support the study's findings that there is much more room for improvement in promoting deeper learning through these methods, as their recommendations to include more reflective practices in the curriculum align with our suggestion for a more balanced approach to enhance students' creative capacities.

In the framework of 21st-century education, Toheri *et al.* (2020) investigate how well various learning models foster students' capacity for critical and creative thought. Eighth-grade students from three classes participated in the study: one received contextual learning instruction, one received problem-posing lessons, and the third functioned as a control group. The findings showed that problem-posing and contextual learning both had a moderately positive impact on improving critical and creative thinking abilities. In particular, compared to expository learning, contextual learning was found to be more successful in enhancing critical thinking, while problem-posing was more advantageous in promoting creative thinking.

4.3 Mathematics Achievement of the Respondents

This ability to apply mathematical concepts reflects the degree of mathematics achievement among respondents. This study was checked through tests, quizzes, and other evaluation tools. High mathematical achievement is then characterized by solid

concepts mastered, successful problem-solving, and the relation of mathematical principles to everyday situations. An understanding of key concepts can be missing or result in errors with calculations while solving equations on the low achievement side. The mathematics achievement of respondents is evaluated to provide evidence for intervention plans, instructional designs, and strategies that will improve such a situation.

Table 4: Level of mathematics achievement of the respondents

Level	**Numerical Range**	**f**	**%**
Outstanding	90-100	47	18.80
Very Satisfactory	85-89	75	30.00
Satisfactory	80-84	82	32.80
Fairly Satisfactory	75-79	46	18.40
Did not meet the Expectations	below 75	0	0.00
Total		**250**	**100.00**
Mean		84.72	
St. Dev.		4.95	

Table 4 presents the level of mathematics achievement by respondents according to the numerical range and its corresponding percentage of respondents in each category. Most respondents were found between the categories Very Satisfactory and Satisfactory, with 30% and 32.8%, respectively. A significant proportion, 18.8%, attained Outstanding scores, while 18.4% had Fairly Satisfactory scores. No respondents scored below 75; hence, all met expectations for mathematics achievement. The mean score of 84.72 indicates that, on average, respondents have a satisfactory understanding of the subject, though there is always room for improvement.

The results show that many respondents are doing well in mathematics, with a large proportion at a satisfactory or better level. However, efforts should be made to move students from satisfactory to outstanding achievement levels. More targeted interventions could be applied to those in the reasonably satisfactory category to increase their performance. While the overall performance is positive, some focused attention will be given to strengthening those key areas to increase the number of students in the Outstanding category and ensure none drop into the Fairly Satisfactory range.

It is commonly acknowledged that a significant factor influencing student and academic achievement is socioeconomic status (SES). SES, however, is frequently not a variable that can be changed to enhance academic performance. Ersan and Rodriguez (2020) investigated additional elements of the educational and student environments that could be changed to lessen achievement gaps, especially in Turkey. According to the findings, SES is a major predictor of achievement, and its impact is greater at the school level than it is at the student level. Higher achievement was found to be positively correlated with early literacy and numeracy activities, preschool education, intrinsic motivation, and participation in instruction. Even after controlling for SES, mathematics achievement at the school level was significantly positively correlated with both school

readiness and the quality of instruction. The study suggests encouraging early literacy and numeracy activities at home as well as preschool education.

To reduce SES-related achievement gaps, parents, educators, and school administrators should also work to create a positive school climate. To predict mathematics achievement among adolescents making the transition to middle school, Semeraro *et al.* (2020) look into the role of both cognitive and non-cognitive factors as well as the quality of the student-teacher relationship. At the beginning of their middle school education, a sizable sample of sixth graders from Italy was evaluated. The findings showed that the best indicator of mathematical success was general cognitive ability. Even after adjusting for self-esteem and the strength of the student-teacher bond, math anxiety remained a significant predictor of achievement among the non-cognitive factors. Furthermore, the study found that the quality of the student-teacher relationship indirectly influenced mathematics achievement by reducing math anxiety. Preventing math anxiety and promoting improved learning outcomes in mathematics may be greatly aided by cultivating a positive student-teacher relationship. This realization has important educational ramifications since it implies that by addressing emotional obstacles like math anxiety, interventions meant to improve student-teacher interactions may improve students' mathematical performance.

According to Barroso *et al.* (2021), there is a strong correlation between math anxiety and academic success, with those who suffer from higher levels of math anxiety typically performing worse in math. Grade level, the kind of math anxiety scale being used, and a person's aptitude for math all have an impact on the relationship between anxiety and performance. Math anxiety was found to have a greater effect on achievement than statistics anxiety, and the effect is less pronounced in lower-level math exams and for individuals with lower math abilities.

4.4 Test of the Relationship between Creative Thinking Skills, Creative Thinking Activities Exposure, and Mathematics Achievement

The tests aimed to verify whether there is a correlation between the identified variables in the study.

Table 5 revealed a moderate positive correlation between CTS and CTAE($r=0.569$, $p<0.001$), while no significant correlations were found between CTS and MA($r=-0.101$, $p>0.01$), CTAE and MA($r=-0.058$, $p>0.01$).

Table 5: Correlation analysis

		1	**2**	**3**
1	CTS	1		
2	CTAE	0.569***	1	
3	MA	-0.101	-0.058	1

Legend: CTS=Creative Thinking Skills; CTAE= Creative Thinking Activities Exposure; MA=Mathematics Achievement

***significant at $p<0.001$

The moderate positive correlation between creative thinking skills and exposure to creative thinking activities confirms the importance of allowing students many opportunities to engage in activities that would develop their creative thinking. Teachers and educators should emphasize such activities to develop students' problem-solving and creativity skills. The findings suggest that exposure to creative activities is vital in developing creative thinking. Schools and educators can further support this development by providing learners with equal and varied opportunities to participate in activities that boost creative problem-solving.

Particularly in high school, when critical thinking and creativity are vital for academic success and future careers, students' creative thinking abilities are critical for problem-solving and innovation. Students gain these abilities when they are exposed to creative thinking-promoting activities like project-based learning, open-ended problem-solving, and group projects. In addition to promoting academic success, fostering creativity in the classroom helps students grow personally and prepares them for challenges in the real world. Students gain the ability to think creatively and approach problems from various angles by participating in such activities.

However, the nonsignificant relationship between creative thinking skills and mathematics achievement of the students hints that although creative thinking is valued in problem-solving, it may not immediately translate to higher math achievement. Other factors, such as foundational skills and test preparation, may more strongly determine students' math outcomes. The results were contradicted by the study of Ndiung *et al.* (2021), which sought to enhance students' mathematical learning outcomes and capacity for creative thought using the Treffinger learning model. Their study found that students who were exposed to the Treffinger model performed noticeably better than their counterparts who were taught using traditional, teacher-centered approaches. These students proved the model's efficacy in fostering vital 21st-century skills like creativity, adaptability, and problem-solving by showcasing improved ideas, logical reasoning, and creative problem-solving abilities. Likewise, Yayuk *et al.* (2020) investigated the particular characteristics of creative thinking at various levels of achievement.

Lastly, the study found that exposure to creative thinking activities is not associated to mathematics achievement. Though creative thinking activities are suitable for cognitive development in general, they may not directly impact math achievement. More academic interventions and targeting of math-specific skills are needed to see real gains in student performance. The results of this study demonstrate that while exposure to creative thinking exercises can enhance students' cognitive capacities, they are not a reliable indicator of mathematical proficiency on their own. Although encouraging creativity can improve abilities like problem-solving, idea generation, and mental flexibility, these advantages do not always lead to improved math test scores. This implies that other factors, such as students' motivation, learning styles, classroom atmosphere, and foundational math skills, might play a more significant role in determining mathematical success. To provide a more comprehensive understanding of the factors influencing math achievement and to guide more targeted educational

interventions, future research is encouraged to investigate additional variables that may better explain students' mathematical performance.

Jonsson *et al.* (2020) examined whether assignments that required students to develop their solutions (Creative Mathematical Reasoning, or CMR) or tasks that provided instructions (Algorithmic Reasoning, or AR) improved their mathematical reasoning and problem-solving abilities. While students in AR follow preset steps, those in CMR grapple with mathematics by creating their own problem-solving strategies. To investigate their effects on learning, the study also included factors such as working memory and fluid intelligence.

The results demonstrated the value of encouraging creativity and problem-solving autonomy by showing that students who practiced with CMR tasks outperformed those who used AR tasks on both practiced and transfer tasks. Although cognitive ability significantly impacted learning under both conditions, students' choice of math track did not substantially affect outcomes. This implies that promoting deeper comprehension and better learning outcomes requires encouraging mathematical struggle through CMR tasks. By examining the contributions of critical, reflective, and creative thinking to academic success, Uğur (2020) provides further evidence in support of this assertion. Students can process information more efficiently and perform better academically when they employ critical thinking, which involves logically analyzing, assessing, and synthesizing information.

Reflective thinking allows students to evaluate their own learning experiences, identify their strengths and weaknesses, and enhance their strategies, leading to improved results. Additionally, students benefit greatly from creative thinking, which fosters original idea generation and innovative problem-solving. These three modes of thinking are interconnected, and when combined, they significantly enhance students' academic achievement. Students who demonstrate high levels of critical, reflective, and creative thinking are more likely to succeed in their studies, as these cognitive skills enable them to approach problems from multiple perspectives and refine their learning strategies.

5. Conclusion

The study’s findings highlight the importance of shaping students’ mathematics learning experiences through activities that foster creative thinking skills. Students’ moderate level of creative thinking skills demonstrated the need to enhance their exposure to activities fostering such skills. However, the potential disconnect of creative thinking to students’ mathematics achievement suggests the need to explore how creative thinking activities are delivered and how their academic success is measured. These results imply that the creative thinking skills enhancement needs to be aligned with the instructional strategies and assessment practices.

Moreover, the association between students’ creative thinking skills and their exposure to creativity thinking activities supplements the importance of meaningful

integration of such experiences in the classroom. Educators may provide activities that are consistent with the daily instructional routines, which include providing students with opportunities to express divergent thinking skills. On the other hand, equipping mathematics teachers with skills to design learner-centered lessons can lead to more holistic student development and foster creative thinking in mathematics to prepare students to think flexibly, solve problems innovatively, and approach challenges with confidence in an increasingly complex world.

Conflict of Interest Statement
The authors declare no conflicts of interest.

About the Authors
Rylle Lhenz Perez is a Teacher III and a graduate of the Master of Arts in Education (MAEd), major in Teaching Mathematics. His research and teaching interests focus on developing students' problem-solving skills and appreciation of mathematics.
Vernie C. Ruiz is a Teacher III and holds a Master of Arts in Education (MAEd), major in Teaching Mathematics. He explores the use of technology and differentiated strategies to support diverse learners in mathematics.
Merce Joy L. Faburada is a Middle School Teacher with a Master of Arts in Education (MAEd), major in Teaching Mathematics. She is particularly interested in learner-centered approaches that promote deeper understanding in mathematics education.
Alfonso A. Lenizo is a Teacher III and completed his Master of Arts in Education (MAEd), major in Teaching Mathematics. He is committed to advancing innovative methods that enhance mathematics learning in the classroom.
Aries Albert A. Abellana is a Middle School Mathematics Teacher and an MAEd graduate major in Teaching Mathematics. His professional interests include curriculum development and strategies for fostering student engagement in mathematics.

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