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The Relationship Between Creative Thinking and Mathematical Literacy in Indonesia: A PISA 2022 Study

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ABSTRACT

Creative thinking has become an important educational competency, particularly following its inclusion as a new domain in PISA 2022. However, empirical evidence regarding its relationship with other academic competencies remains limited, especially in non-OECD educational contexts. This study employed a quantitative secondary data analysis using the PISA 2022 dataset to examine Indonesian students' creative thinking performance and its association with mathematical literacy. The analysis included approximately 13,000 Indonesian students who participated in PISA 2022 and was conducted using OECD-calibrated plausible values in RStudio. Descriptive and correlational analyses were performed to examine the distribution of creative thinking scores and their relationship with mathematical literacy. The results revealed substantial variation in creative thinking performance among Indonesian students. In addition, a Pearson correlation analysis showed a strong positive association between creative thinking and mathematical literacy ($r = 0.67$, $p < .001$). Interpreted through a deep learning lens, these findings suggest that creative thinking and mathematical literacy may share common cognitive foundations related to reasoning, conceptual understanding, and meaningful problem solving. Although the findings do not imply causality, they highlight the importance of learning environments that support deep engagement with mathematical ideas. This study provides empirical evidence on the relationship between creative thinking and mathematical literacy in a non-OECD educational context.

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1. INTRODUCTION

Creativity is not conceptualized as a personal trait or general ability. However, it has been considered as behaviour resulting from particular constellations of individual characteristics, cognitive abilities, and social environments [1], [2]. A person who has

creativity, it also depends on the training they have received, or the simple experiences that they are able to generate ideas by using their own strategies to develop their creativity [3], [4]. OECD [5] argues that creative thinking is students' competence in engaging productively in generating, evaluating, and improving ideas that can result in both original and effective solutions, advance knowledge, and foster imagination. Henriksen et al. [6] and B. Sriraman [7] also found that schools nowadays demand that students be more creative thinkers, as memorization alone is not enough to support students' success; they need to understand complex concepts, generate new ideas, and express them verbally or in writing. Thus, based on this definition, it is crucial to treat thinking and creativity as a PISA domain by focusing on cognitive processes, particularly for 15-year-old students [8].

Leyva et al. [9] revealed that technological advancement and the growing complexity of social and economic challenges have influenced educational systems worldwide to reimagine the skills students need for success in their lives. These dynamic changes require individuals to adapt, innovate, and solve problems without clear precedents. As a result, school curricula are shifting their focus: from traditional curricula to a focus on mastery of disciplinary knowledge, there is an increasing emphasis on flexible thinking, the ability to address novel situations, and the generation of original solutions [10]. In this context, we saw that creativity is no longer simply an educational outcome; it has become a basic competency essential for lifelong learning and effective participation in various societies.

In mathematics education, students who exhibit creativity in thinking are commonly understood as having the ability to produce unusual ideas [11], [7]. Rather, it involves students' capacity to reason flexibly, construct mathematical connections, develop multiple solution strategies, and justify their thinking in meaningful ways [12], [13]. This view positions creative thinking as a domain that is interconnected with conceptual understanding, mathematical reasoning, and problem-solving. Students who engage in flexible and conceptually oriented mathematical thinking are more likely to demonstrate creative approaches when solving non-routine problems [14], [15]. Thus, we can conclude that creativity in mathematics education is also associated with meaningful learning experiences, such as designing learning activities that encourage exploration, interpretation, and reasoning rather than memorization and routine procedures alone.

Researchers have proposed various perspectives on creative thinking, resulting in diverse interpretations of the construct. Some studies in psychological areas defined creativity through varied lenses and interpretations, most of which focused on divergent thinking, focusing on fluency, flexibility, originality, and elaboration [3]. Another recent research, however, has questioned these general definitions, emphasizing that creative thinking is shaped by disciplinary practices, a way to represent knowledge, and specific epistemic goals [4], [5]. In mathematics education practices, the term "creativity" is commonly understood as a particular pattern of thinking that involves a person's ability to construct, transform, and justify mathematical ideas, rather than being focused on how to get the correct answers [6], [7]. Thus, creative thinking in mathematics is closely connected to how students build conceptual understanding, generate ideas, and provide justification.

Some prior research has consistently framed mathematical literacy as a competency that extends beyond procedural competence in applying mathematical concepts;

rather, it requires students' ability to reason conceptually, justify solutions, and apply mathematical knowledge to solve non-routine problems [16], [17]. Furthermore, these definitions suggest a strong connection between creative thinking and mathematical literacy, particularly within an educational system that emphasizes students' fluency in meaningful learning, conceptual understanding, and problem solving. Moreover, empirical research has reported a strong positive association among the domains of mathematical creativity, higher-order reasoning, problem-solving, and conceptual transfer [18], [19].

Baysu et al. [20] argue that PISA, a large international assessment that examines students' reading and mathematics, is the most comprehensive measure of students' outcomes within the OECD. Some research has used PISA data to inform students' performance in mathematical literacy; however, their focus is mostly on how to develop PISA-like tasks for local contexts, particularly in countries like Indonesia [21], [22]. In Indonesia, the gap between curriculum demand and students' outcomes within this measurement remains notable, as students' mathematical literacy and higher-order thinking skills are important domains, and these skills are repeatedly highlighted in national and international reports [23]. We understand that examining how Indonesian students' creative thinking relates to their competencies in mathematical literacy can yield valuable insights for curriculum development, instructional design, and the teaching process, especially for educational reform focused on deep learning and competency-based instruction.

OECD [16] defined mathematical literacy as students' competence that extends beyond procedural reliance, intended to be students' ability to formulate, employ, and interpret mathematics in real-world contexts. Moreover, this competency also requires students to think conceptually, apply mathematical knowledge flexibly, and represent their own understanding meaningfully [24]. Thus, there is a strong connection between mathematical literacy and creative thinking, as they share important cognitive foundations, particularly in developing students' reasoning and conceptual understanding, and in supporting students in terms of how to solve problems.

Several studies have reported positive associations between mathematical creativity, problem solving, and higher-order reasoning [25], [26]. However, empirical studies examining the relationship between creative thinking and mathematical literacy using large-scale international assessment data remain limited, especially in non-OECD countries such as Indonesia. Since creative thinking was introduced as a new domain in PISA 2022, little is known about how Indonesian students' performance in creative thinking relates to mathematical literacy at the national level. This study addresses this gap by analyzing PISA 2022 data to examine the distribution of creative thinking performance and its association with mathematical literacy among Indonesian students. This gap is important because improving higher-order thinking and competency-based learning has become a major educational priority in Indonesia [27]. Understanding how creative thinking relates to mathematical literacy may therefore provide important implications for mathematics instruction, curriculum development, and educational equity. Due to these concerns, this study investigates Indonesian students' creative thinking performance using PISA 2022 data and examines its relationship with mathematical literacy. In particular, we address two focuses of this study:

1. Describe the distribution of Indonesian students' creative thinking performance.
2. Examine the relationship between creative thinking and mathematical literacy.

By addressing these objectives, this study contributes empirical evidence to discussions on creativity and mathematical literacy within the Indonesian context.

2. LITERATURE REVIEW

Creative Thinking in Educational Research

One important area in educational and psychological research is students' ability in creative thinking, although its conceptualization has evolved considerably over time. Rábanos [28] framed creativity as a person's ability, associated with divergent thinking, fluency, flexibility, originality, and elaboration, to respond to a particular task (e.g., an open-ended task). Another scholar, Zhao & Abdullah [29], added that global demand nowadays seeks CT as a highly in-demand competencies that also support students' critical thinking. Thus, from these perspectives, creativity was often treated as a global skill that every student is expected to have in preparing for their future.

More recent researchers, however, have challenged the idea that "creativity" is innate and not connected to cognitive skill. Modern researchers increasingly argue that creative thinking is shaped by some factors-disciplinary knowledge, social interaction, representational practices, and specific epistemic goals rather than seeing creativity as the product of generating ideas. K. Vorhölter & B. Schwarz [30] emphasized that CT develops through meaningful learning settings, particularly when individuals get involved in meaningful learning activities in a supportive environment.

Within an educational research perspective, this shift has led to growing attention toward the role of classroom contexts and instructional practices in fostering students' creativity. Beghetto & Kaufman [31] suggest that CT is more likely to empower students to explore their ideas, reflect on their ways of thinking, collaborate with peers, and engage in meaningful problem-solving. Some recent systematic literature reviews indicate that instructional environments emphasizing student agency, inquiry, conceptual understanding, and reflective learning support the development of creative thinking more effectively than other approaches focused on memorization and procedural repetition [32]. Further, these findings suggest that creative thinking is closely connected to the meaningful learning process and cannot be separated from pedagogical conditions.

Importantly, the growing emphasis on creativity in education has also encouraged researchers to examine how creative thinking is expressed differently across disciplines. As a result, creativity in mathematics education is increasingly understood not merely as originality, but as students' ability to reason flexibly, construct mathematical connections, and engage meaningfully with mathematical ideas.

Creative Thinking in Mathematics Education

Within mathematics education, creative thinking is increasingly understood as an essential component of mathematical reasoning rather than simply the production of unusual or original ideas [33], [6]. Creativity in mathematics involves students' ability to interpret

problems flexibly, construct meaningful mathematical connections, generate multiple solution strategies, and justify their reasoning in conceptually grounded ways [25]. From this perspective, mathematical creativity is closely related to conceptual understanding, adaptive reasoning, and meaningful engagement with mathematical ideas. Creative thinking had a positive impact on students' performance in mathematics, as students who focused on CT strategies demonstrated significantly higher performance in thinking mathematically.

Several scholars have emphasized that creative mathematical thinking emerges when students move beyond routine procedures and engage in non-routine problem solving. Students who are able to approach problems from multiple perspectives, evaluate alternative strategies, and explain their reasoning tend to demonstrate higher levels of mathematical creativity [7], [34]. Thus, creativity in mathematics is not limited to finding correct answers, but also involves the flexibility and depth of students' mathematical thinking processes.

Previous research has consistently shown that instructional environments play an important role in fostering mathematical creativity [35]. Classroom practices that encourage exploration, discussion, open-ended tasks, and multiple solution pathways are more likely to support students' creative mathematical thinking than instructional approaches focused primarily on memorization and procedural repetition [36]. In such learning environments, students are encouraged to reason conceptually, communicate mathematical ideas, and construct understanding collaboratively.

This perspective aligns with broader views of meaningful learning in mathematics education, where reasoning, interpretation, and conceptual understanding are emphasized as central aspects of students' mathematical development. As a result, mathematical creativity is increasingly associated with learning environments that promote flexible thinking, reflective engagement, and meaningful problem solving rather than surface-level procedural performance alone [37].

Despite growing interest in mathematical creativity, much of the existing research has been conducted within small-scale or classroom-based settings. Although these studies provide important insights into students' creative mathematical processes, fewer studies have explored mathematical creativity using large-scale international assessment data. Consequently, there remains limited empirical understanding of how creative thinking relates to broader mathematical competencies, such as mathematical literacy, within national educational contexts.

Creative Thinking in PISA 2022

Due to the increasing attention on CT globally, PISA, as an international large-scale educational assessment, has included CT as a new domain in the PISA 2022 measurement. The OECD explicitly assessed students' CT competencies alongside other remaining domains such as mathematics, reading, and science [38], [39].

According to the OECD framework, CT refers to students' competency in generating, evaluating, and developing their ideas in ways that are both original and meaningful across different contexts. Specifically, PISA conceptualizes CT not as artistic talent or innate giftedness, but as a cognitive process that relates to reasoning, problem solving, interpretation, and knowledge application [40]. As a result, this definition posits CT

as a competency that can be developed and enriched through educational experiences and meaningful learning environments.

In PISA 2022, CT assessment was developed to capture students' capacities across layered processes, including idea generation, idea evaluation, and idea improvement. Within this assessment, PISA focused on students' ability to respond flexibly and thoughtfully to problems (e.g., open-ended and unfamiliar situations) rather than using their memories of knowledge. In this way, CT in PISA reflects broader educational goals associated with adaptive reasoning, conceptual understanding, and flexible problem solving. In addition, the inclusion of CT in PISA 2022 also provides meaningful opportunities to examine creativity using internationally comparable data. Collecting data through a large assessment scale also allows researchers to investigate patterns of CT performance across student populations and explore how CT relates to the other academic competencies, particularly in mathematical literacy.

Some empirical research utilizing PISA 2022, particularly in the CT domain, remains relatively limited, particularly in Global South countries [41]. The existing studies have primarily focused on cross-country comparisons and descriptive trends of students' performance; however, fewer studies have explored the relationship between creative thinking and other learning competencies within specific national contexts (PISA 2022). This gap is important in countries such as Indonesia, where educational goals increasingly emphasize higher-order thinking skills, competency-based learning, and meaningful student engagement.

Linking Creative Thinking and Mathematical Literacy

Conceptually, both CT and mathematical literacy share a similar important cognitive base. Mathematical literacy focuses on how students are able to formulate, apply, and interpret mathematics in various real-world contexts rather than simply using routine procedures [42]. This competency requires students to create reasoning conceptually, interpret information flexibly, evaluate possible solutions, and be able to adapt mathematical knowledge to unfamiliar situations. Such a process closely aligns with core dimensions of CT. Similarly, CT is a process that involves students' capacity to generate ideas, approach problems from multiple perspectives, evaluate alternatives, and construct meaningful responses in open-ended ways. In mathematics learning, these processes are particularly essential because they require students' flexible reasoning, conceptual interpretation, and adaptive thinking rather than relying solely on procedures. In fact, students with strong mathematical literacy may also demonstrate higher levels of CT.

Some previous studies have reported positive relations between mathematical creativity, higher-order reasoning, and problem-solving performance [7]. Research focused on mathematics education suggests that instructional practices emphasize mathematical literacy in conceptual understanding, inquiry, exploration, and meaningful problem solving. These findings indicate that the connection between mathematical literacy and CT may emerge from shared learning experiences that encourage reasoning, interpretation, and conceptual engagement [43].

Despite these conceptual connections, empirical studies examining the relationship between creative thinking and mathematical literacy using large-scale assessment data remain limited, particularly in non-OECD contexts such as Indonesia. Existing research has often focused on creativity or mathematical achievement separately, while fewer studies have investigated how these competencies relate within broader educational systems [29]. Therefore, examining the relationship between creative thinking and mathematical literacy among Indonesian students using PISA 2022 data may contribute important empirical evidence to current discussions on mathematics education, creativity, and educational equity.

3. METHOD

Data Source and Sample

This study utilized secondary data from the Programme for International Student Assessment (PISA) 2022 conducted by the Organisation for Economic Co-operation and Development (OECD) using the CT dataset. This study focused specifically on Indonesian students' performance in PISA 2022. After restricting the dataset to Indonesia, approximately 13,000 students were included in the analysis. According to the literature, examining Indonesia as a specific case provides an opportunity to explore students' creative thinking and mathematical literacy within a specific educational context while remaining connected to broader international discussions on higher-order thinking and competency-based education.

Measures

Creative Thinking (CT)

CT performance was measured using the Creative Thinking domain introduced in PISA 2022. Student performance was represented using ten plausible values (PV1CREAT–PV10CREAT) provided by the OECD. Plausible values are multiple imputed proficiency estimates derived from item response theory (IRT) models and are designed to support population-level analyses rather than individual-level diagnosis. To obtain a single estimate for descriptive and relational analyses, the mean of the ten plausible values was calculated for each student. This approach is commonly applied in secondary analyses of PISA data and provides a stable estimate of students' creative thinking performance.

Mathematical Literacy

Mathematical literacy was measured using the mathematical literacy domain task, which included its contexts (e.g., space and shapes, statistics and probability) in PISA 2022. Similar to creative thinking, mathematical literacy scores were represented using ten plausible values (PV1MATH–PV10MATH). These plausible values reflect students' ability in three ways (formulate, apply, and interpret mathematics) in various real-world situations. Similar to CT, in order to obtain a composite mathematical literacy score, the average of the ten plausible values was calculated for each student. Thus, this procedure aligns with common practices in large-scale assessment analyses utilizing PISA data.

Missing Data Treatment

Cases with missing values on the variables required for the analyses were excluded using listwise deletion. Because the primary variables were derived from OECD-provided plausible values, the proportion of missing data was minimal and did not substantially affect the sample size.

Data Analysis

Data analysis was conducted using free-access software, RStudio version 4.6.0, in several stages. Four steps within this process are described in Table 1 below. All analyses relied on OECD-calibrated plausible values provided in the PISA 2022 dataset without re-estimating item or person parameters. This analytical approach maintains methodological consistency with prior PISA-based educational research.

Table 1. Steps in Data Analysis

Stage	Analysis Technique	Purpose	Variables / Outputs
1	Descriptive Statistics	To examine the overall distribution of Indonesian students' CT performance	Minimum scores, maximum scores, mean scores, median scores, quartiles, and quantile distributions
2	Visual Analysis	To explore patterns of score distribution and identify variations in students' CT performance	Histograms and boxplots of creative thinking scores
3	Quantile Analysis	To investigate disparities in CT performance among lower-, middle-, and higher-performing students	Quantile group comparisons and distributional differences
4	Pearson Correlation Analysis	To examine the relationship between CT and mathematical literacy without implying causal relationships	Correlation coefficient, strength, and direction of association between CT and mathematical literacy

Prior to the correlation analysis, scatterplots were examined to assess the linearity of the relationship between creative thinking and mathematical literacy. Pearson correlation was selected because both variables were continuous and the primary objective was to examine the strength and direction of their association rather than to establish causal relationships.

The present study focused on descriptive and correlational patterns. Student sampling weights and replicate weights were not incorporated into the analysis. Therefore, findings should be interpreted as indicative of patterns within the Indonesian PISA 2022 sample rather than as weighted national estimates. Future studies may extend this work using the full OECD weighting procedures and multilevel modelling approaches.

4. RESULTS AND DISCUSSION

4.1 Results

Overall Creative Thinking Performance

The overall performance of Indonesian students in CT based on PISA 2022 data is presented, with scores calculated using the average of the ten plausible values provided by the OECD, and the results show that Indonesian students demonstrated a moderate level of creative thinking performance, with a mean score of 20.65 (SD= 8.74) and a median score

of 19.04. Scores ranged from 0.52 to 57.86, with this value indicating substantial variation in students' creative thinking performance. The details of descriptive statistics for Indonesian students' creative thinking scores are presented in Table 2.

Table 2. Descriptive Statistics of Creative Thinking Scores

Statistic	Value
N	13,214
Mean	20.65
SD	8.74
SE	0.08
95% CI	20.49–20.81
Median	19.04
Min	0.52
Max	57.86

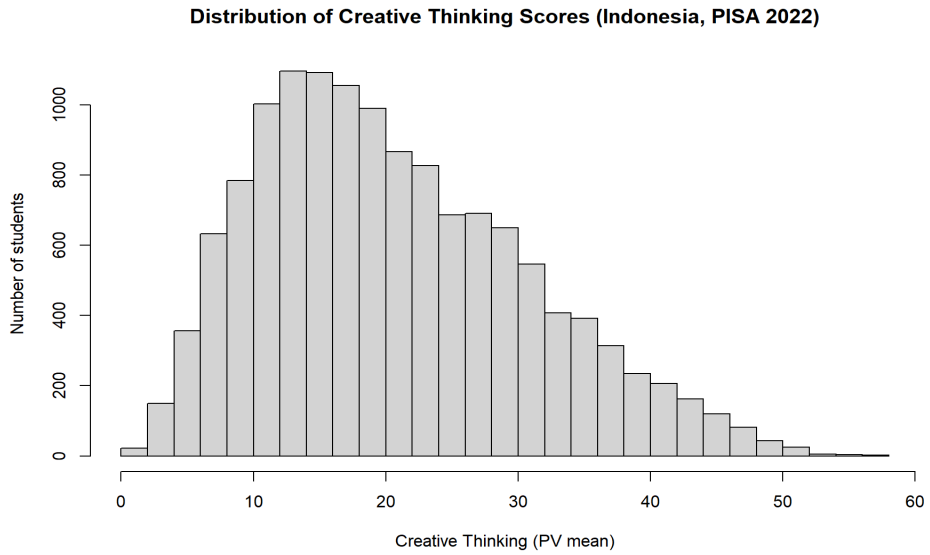


Figure 1. Distribution of Creative Thinking Scores Among Indonesian Students (PISA 2022)

The histogram (Figure 1) shows the distribution of CT scores among Indonesian students. While a smaller proportion of students achieved relatively high creative thinking scores, a considerable number of students were concentrated at the lower end of the distribution. This pattern indicates that creative thinking competencies are not evenly distributed across the student population and that students' creative thinking performance varies substantially within the Indonesian educational context.

Distributional Inequality in Creative Thinking

To further assess variation in creative thinking performance, this work also conducted a quantile analysis. The results revealed there is a clear disparity among students. According to the analysis, the lowest-performing 10% of students obtained scores of 8.58 or below, while the highest-performing 10% achieved scores of 35.17 or higher. Moreover, the interquartile distribution shows a considerable gap between lower- and higher-performing

populations. These findings suggest that creative thinking competencies are not equally distributed across the student population.

Table 2. Quantile Analysis

Quantile	Score
0%	0.52
10%	8.58
25%	12.80
50% (Median)	19.04
75%	27.53
90%	35.17
100%	57.86

The boxplot (Figure 2) also represents the CT scores among Indonesian students. The visualization confirms the presence of wide variability in students' performance. The relatively large interquartile range and the presence of several high-scoring outliers indicate that although some students demonstrated strong creative thinking competencies, many others remained at comparatively lower levels.

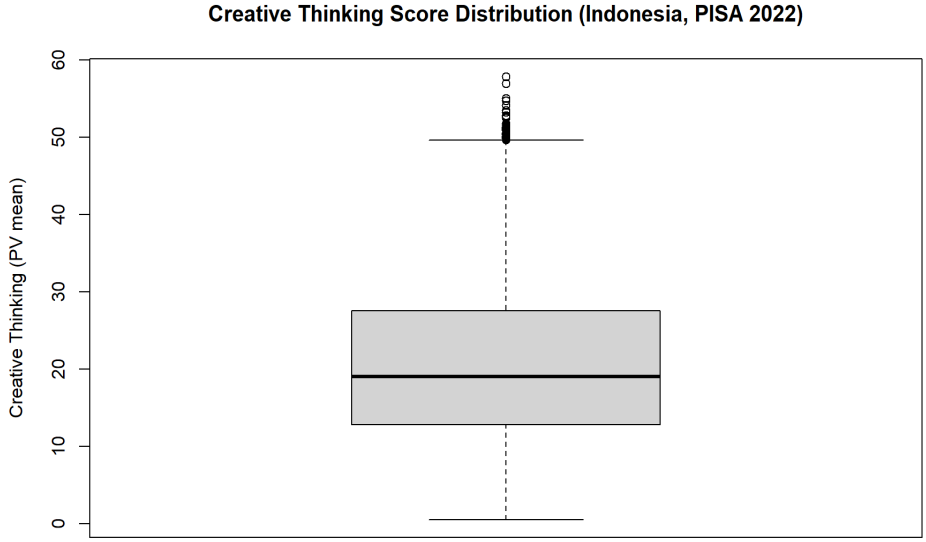


Figure 2. Boxplot of Creative Thinking Scores in Indonesia (PISA 2022)

These findings indicate substantial disparities in creative thinking performance among Indonesian students. Such disparities underscore the importance of examining broader educational conditions that may influence the development of higher-order thinking skills.

Relationship Between Creative Thinking and Mathematical Literacy

By using Pearson analysis, the relationship between creative thinking and mathematical literacy is examined using Pearson correlation analysis. Mathematical Literacy scores in PISA 2022 were calculated as the average of the plausible values from its dataset.

The results show a strong positive association between creative thinking and mathematical literacy ($r=0.67$, $p < .001$).

In Figure 3, students with higher mathematical literacy scores generally demonstrated stronger CT skills. Accordingly, the upward pattern in the scatterplot indicates a strong relationship between the two competencies. Although this analysis does not establish causality, the strength of the correlation suggests that CT is closely connected with students' ability to reason, interpret, and apply mathematical knowledge in meaningful contexts, which are the domain of mathematical literacy.

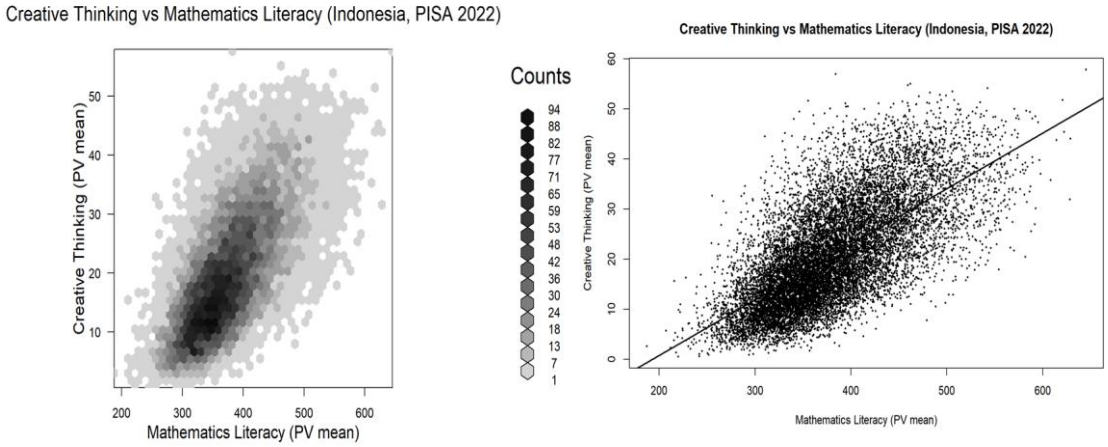


Figure 3. Density of Students' Creative Thinking and Mathematical Literacy Scores in Indonesia (PISA 2022)

4.2 Discussion

This study examined Indonesian students' creative thinking performance using PISA 2022 data and explored its relationship with mathematical literacy. The findings revealed a positive association between creative thinking and mathematical literacy. Students with higher mathematical literacy scores tended to demonstrate stronger creative thinking performance. Although these findings do not establish causality, they suggest that the two competencies are closely related in the Indonesian PISA 2022 sample.

The Association Between Mathematical Literacy and Creative Thinking

This study reveals a strong positive relationship between creative thinking and mathematical literacy. The result of the correlation coefficient indicates that students with higher mathematical literacy scores tended to demonstrate stronger creative thinking performance. According to the prior research, creative thinking in mathematics is closely connected with conceptual understanding, flexible reasoning, and the ability to generate and evaluate multiple solution strategies [7], [34]. Collectively, these studies suggest that creative thinking is embedded in students' capacity to reason mathematically and apply ideas meaningfully across contexts.

This finding is consistent with previous research suggesting that mathematical creativity is closely associated with conceptual understanding, higher-order reasoning, and problem-solving performance [7], [29]. Similarly, Leikin et al. [38] argued that students who

engage in flexible reasoning and multiple-solution strategies are more likely to demonstrate creative mathematical thinking. Therefore, the present study extends prior classroom-based findings by providing evidence from a large-scale international assessment dataset.

According to the PISA definition, mathematical literacy emphasizes students' ability to reason, model, interpret, and communicate rather than routine procedural computation [42]. Through this definition, deep learning is understood through a pedagogical view; it focuses on sense-making, argumentation, and the integration of mathematical ideas across representations and real-world situations [44], [45]. In addition, recent empirical findings indicate that instructional practices should support connection, exploration, and explanation, and multiple solutions that support both mathematical understanding and creative thinking [35]. Together, these perspectives suggest that mathematical literacy and creative thinking may share common cognitive foundations, particularly reasoning, conceptual understanding, and meaningful problem solving. Consequently, learning environments that promote deep engagement with mathematical ideas may support the development of both competencies simultaneously.

These findings should not be interpreted as evidence of a causal relationship between mathematical literacy and creative thinking. Rather, they suggest that both competencies may co-develop reciprocally within learning environments that support deep, conceptually oriented student engagement. This perspective is consistent with research arguing that creativity in education is embedded in sustained classroom practices, such as teachers providing opportunities for reflection, fostering collaboration, and encouraging intellectual risk, rather than from isolated creativity-focused activities [26]. Thus, these results underscore the importance of instructional quality in fostering creative thinking through mathematics learning.

Implications for Mathematics Teaching and Assessment

Another point to consider is the gap in creative thinking abilities among students. This difference underscores the importance of ensuring everyone has access to rich learning experiences. If learning environments that emphasize deep understanding are associated with stronger creative thinking, differences in instructional quality may contribute to variation in students' creative thinking outcomes. Solving this challenge means not only rethinking the curriculum, but also supporting teachers through ongoing training so they can create learning environments centered on deep understanding.

Lastly, these results show that broad assessment data, such as PISA, can be useful for more than just measuring how well students perform. By looking at creative thinking and math literacy side by side, this study shows how assessment results can spark broader conversations about which teaching practices really help students learn in creative and meaningful ways.

Limitations and Future Research

Several limitations should be acknowledged. First, this study employed a correlational design and therefore cannot establish causal relationships between creative thinking and mathematical literacy. Second, the analysis relied on cross-sectional PISA 2022

data, which limits conclusions regarding developmental changes over time. Third, the study focused only on creative thinking and mathematical literacy and did not include socioeconomic, demographic, school-level, or instructional variables that may influence student performance. Finally, the findings were based on OECD plausible values and should be interpreted within the constraints of secondary data analysis. Future studies may employ regression analysis, multilevel modelling, or comparative cross-country analyses to investigate further factors associated with students' creative thinking development.

5. CONCLUSION

This study examined Indonesian students' CT performance using the PISA 2022 dataset and explored its relationship with mathematical literacy within the Indonesian educational context. The findings also reveal that Indonesian students demonstrated substantial variation in CT performance, with considerable disparities between lower- and higher-performing students. According to the quantile analysis, CT was unevenly distributed across the student population.

In addition, the findings demonstrated a strong positive relationship between creative thinking and mathematical literacy, and students with stronger mathematical literacy also demonstrated higher creative thinking performance. Although the findings do not imply causal relationships, they suggest that both competencies may develop together within learning environments that emphasize reasoning, conceptual understanding, interpretation, and meaningful problem solving.

This study contributes empirical evidence to current discussions on creativity, mathematical literacy, and competency-based learning in Indonesia, particularly following the introduction of creative thinking in PISA 2022. The findings also suggest the importance of paying greater attention to unequal patterns of higher-order thinking development among students. Finally, future research may expand this study by utilizing broader PISA datasets containing demographic, instructional, and socioeconomic variables to investigate further factors associated with students' creative thinking development in mathematics education.

REFERENCES

[1] T. M. Amabile, "p INDIVIDUAL The Social Psychology of Creativity : A Componential Conceptualization," vol. 45, no. 2, pp. 357–376, 1983.
[2] T. M. Amabile, "Componential Theory of Creativity," 2012.
[3] T. M. Amabile and M. G. Pratt, "Research in Organizational Behavior The dynamic componential model of creativity and innovation in organizations : Making progress, making meaning $," Res. Organ. Behav., vol. 36, pp. 157–183, 2016, doi: 10.1016/j.riob.2016.10.001.
[4] T. M. Amabile, "Motivation and Creativity : Effects of Motivational Orientation on Creative Writers," vol. 48, no. 2, pp. 393–399, 1985.
[5] C. E. Summaries, "What Students Know and Can Do," PISA 2009 a Glance, vol. I, 2019, doi: 10.1787/g222d18af-en.
[6] D. Henriksen et al., "Creativity and Technology in Education: An International Perspective," Technol. Knowl. Learn., vol. 23, no. 3, pp. 409–424, 2018, doi: 10.1007/s10758-018-9380-1.
[7] B. Sriraman, "The Characteristics of Mathematical Creativity," vol. 14, no. 1, pp. 19–34, 2004.
[8] H. Kang and L. Cogan, "The Differential Role of Socioeconomic Status in the Relationship between Curriculum-Based Mathematics and Mathematics Literacy: the Link Between TIMSS and PISA," Int. J. Sci. Math. Educ., vol. 20, no. 1, pp. 133–148, 2022, doi: 10.1007/s10763-020-10133-2.
[9] L. A. Leyva, R. Quea, K. Weber, D. Battey, and D. López, "Detailing Racialized and Gendered Mechanisms of Undergraduate Precalculus and Calculus Classroom Instruction," Cogn. Instr., vol. 39, no. 1, pp. 1–34, 2021, doi: 10.1080/07370008.2020.1849218.
[10] A. Ozkale and E. Ozdemir Erdogan, "An analysis of the interaction between mathematical literacy and financial

literacy in PISA*," Int. J. Math. Educ. Sci. Technol., 2020, doi: 10.1080/0020739X.2020.1842526.
[11] L. L. Hadar and M. Tirosh, "Creative thinking in mathematics curriculum : An analytic," Think. Ski. Creat., vol. 33, no. July, p. 100585, 2019, doi: 10.1016/j.tsc.2019.100585.
[12] C. Kooloos, H. Oolbekkink-Marchand, S. van Boven, R. Kaenders, and G. Heckman, "Building on student mathematical thinking in whole-class discourse: exploring teachers' in-the-moment decision-making, interpretation, and underlying conceptions," J. Math. Teach. Educ., vol. 25, no. 4, pp. 453–477, 2022, doi: 10.1007/s10857-021-09499-z.
[13] A. A. Saefudin, A. Wijaya, S. Irene, and A. Dwiningrum, "Review Article Mapping research trends in mathematical creativity in mathematical instructional practices : A bibliometric analysis," vol. 7, no. 4, pp. 439–458, 2023.
[14] H. G. Weigand, J. Trgalova, and M. Tabach, "Mathematics teaching, learning, and assessment in the digital age," ZDM - Math. Educ., 2024, doi: 10.1007/s11858-024-01612-9.
[15] L. Ladachart, S. Khamlarsai, and W. Phothong, "Cultivating a Design Thinking Mindset in Educationally Disadvantaged Students Using a Design-based Activity," Int. J. Innov. Sci. Math. Educ., vol. 30, no. 4, pp. 1–14, 2022, doi: 10.30722/IJISME.30.04.001.
[16] OECD, Pisa 2022 Results, vol. I. 2023. [Online]. Available: https://www.oecd-ilibrary.org/education/pisa-2022-results-volume-i_53f23881-en%0Ahttps://www.oecd.org/publication/pisa-2022-results/country-notes/germany-1a2cf137/
[17] Anis Munfarikhatin, "Analisis karakter kerja keras dan literasi matematika pisa siswa melalui pembelajaran model pbl strategi murder materi pythagoras," Universitas Negeri Semarang, 2016.
[18] I. Santia, Purwanto, A. Sutawidjadja, Sudirman, and Subanji, "Exploring mathematical representations in solving ill-structured problems: The case of quadratic function," J. Math. Educ., vol. 10, no. 3, pp. 365–378, 2019, doi: 10.22342/jme.10.3.7600.365-378.
[19] N. S. Baanqud, H. Al-Samarraie, A. I. Alzahrani, and O. Alfarraj, "Engagement in cloud-supported collaborative learning and student knowledge construction: a modeling study," Int. J. Educ. Technol. High. Educ., vol. 17, no. 1, 2020, doi: 10.1186/s41239-020-00232-z.
[20] G. Baysu, O. Agirdag, and J. De Leersnyder, "The Association Between Perceived Discriminatory Climate in School and Student Performance in Math and Reading: A Cross-National Analysis Using PISA 2018," J. Youth Adolesc., pp. 619–636, 2022, doi: 10.1007/s10964-022-01712-3.
[21] A. Munfarikhatin, "FENOMENA LITERASI MATEMATIKA SISWA DI INDONESIA BERDASARKAN HASIL PISA," Pembelajaran dan Pengemb. Mat., vol. 2, no. 1, 2022.
[22] I. Pratiwi, "Efek Program Pisa Terhadap Kurikulum Di Indonesia," J. Pendidik. dan Kebud., vol. 4, no. 1, p. 51, 2019, doi: 10.24832/jpnk.v4i1.1157.
[23] Q. Wu, D. Debeer, J. Buchholz, J. Hartig, and R. Janssen, "Predictors of individual performance changes related to item positions in PISA assessments," Large-Scale Assessments Educ., vol. 7, no. 1, 2019, doi: 10.1186/s40536-019-0073-6.
[24] M. Holenstein, G. Bruckmaier, and A. Grob, "Transfer effects of mathematical literacy: an integrative longitudinal study," Eur. J. Psychol. Educ., vol. 36, no. 3, pp. 799–825, 2021, doi: 10.1007/s10212-020-00491-4.
[25] J. Lithner, "A research framework for creative," pp. 255–276, 2008, doi: 10.1007/s10649-007-9104-2.
[26] A. D. Saavedra, "Chavacano as a medium of instruction: Its implications for the reading levels of english in elementary school pupils," Int. J. Innov. Creat. Chang., vol. 10, no. 10, pp. 311–320, 2020, doi: 10.2139/ssrn.3620807.
[27] C. Sadijah, W. Murtafiah, L. Anwar, R. Nurhakiki, and E. T. D. Cahyowati, "Teaching higher-order thinking skills in mathematics classrooms: Gender differences," J. Math. Educ., vol. 12, no. 1, pp. 159–179, 2021, doi: 10.22342/jme.12.1.13087.159-180.
[28] N. Larraz-Rábanos, "Development of Creative Thinking Skills in the Teaching-Learning Process," in Teacher Education - New Perspectives, U. Kayapinar, Ed., London: IntechOpen, 2021. doi: 10.5772/intechopen.97780.
[29] S. Zhao and A. H. Abdullah, "E nhancing Undergraduates ' Creative Thinking through Mathematics Courses : A Systematic Literature Review," vol. 18, no. 4, pp. 39–56, 2025.
[30] K. Vorhölter and B. Schwarz, "Fostering Students' Construction of Meaningfulness of Mathematics with Mathematical Modelling Problems," in Mathematical Modelling Education and Sense-making, G. A. Stillman, G. Kaiser, and C. E. Lampen, Eds., Cham: Springer International Publishing, 2020, pp. 323–333. doi: 10.1007/978-3-030-37673-4_28.
[31] R. A. Beghetto and J. C. Kaufman, "Classroom contexts for creativity," High Abil. Stud., vol. 25, no. 1, pp. 53–69, 2014, doi: 10.1080/13598139.2014.905247.
[32] E. Tavsancil, O. Yildirim, and S. Bilican Demir, "Direct and indirect effects of learning strategies and reading enjoyment on PISA 2009 reading performance," Eurasian J. Educ. Res., vol. 2019, no. 82, pp. 169–190, 2019, doi: 10.14689/ejer.2019.82.9.
[33] J. C. Kaufman and R. A. Beghetto, "Beyond Big and Little: The Four C Model of Creativity," Rev. Gen. Psychol., vol. 13, no. 1, pp. 1–12, 2009, doi: 10.1037/a0013688.
[34] R. Leikin, R. Subotnik, F. Mihaela, and S. Ildiko, "Teachers ' views on creativity in mathematics education : an international survey," pp. 309–324, 2013, doi: 10.1007/s11858-012-0472-4.
[35] J. Boaler, Experiencing School Mathematics: Traditional and Reform Approaches to Teaching and Their Impact on Student Learning, Rev. and expanded ed. in Studies in mathematical thinking and learning. Mahwah, N.J. ; London: Routledge, 2002.

[36] B. R. Zubković, R. Pahljina-reinić, and S. Kolić-, "Age and gender differences in mathematics learning during school transition," Int. J. Sch. Educ. Psychol., vol. 00, no. 00, pp. 1–14, 2021, doi: 10.1080/21683603.2021.1934206.
[37] K. Sing, T. Sheau, W. Lin, and B. Kaur, "Mapping and Extending the Theoretical Perspectives of Reading in Science and Mathematics Education Research," Int. J. Sci. Math. Educ., no. 0123456789, 2022, doi: 10.1007/s10763-022-10322-1.
[38] S. Field, M. Kuczera, and B. Pont, No more failures: Ten steps to equity in education, 1st ed. in Education and training policy. Paris: OECD, 2007.
[39] A. M. Dockery, P. Koshy, and I. W. Li, "Culture, migration and educational performance: a focus on gender outcomes using Australian PISA tests," Aust. Educ. Res., vol. 47, no. 1, pp. 39–59, 2020, doi: 10.1007/s13384-019-00321-7.
[40] OECD, "PISA 2015 Result in Focus," 2018.
[41] K. Stacey, "The PISA view of mathematical literacy in Indonesia," J. Math. Educ., vol. 2, no. 2, pp. 95–126, 2011, doi: 10.22342/jme.2.2.746.95-126.
[42] K. Yasukawa, "The Role of National Media in Adult Literacy and Numeracy Policy: a Case Study from Australia," Can. J. Sci. Math. Technol. Educ., vol. 19, no. 1, pp. 35–47, 2019, doi: 10.1007/s42330-018-0038-8.
[43] L. Tikly, "Towards a framework for researching the quality of education in low-income countries," Comp. Educ., vol. 47, no. 1, pp. 1–23, 2011.
[44] M. Fullan, J. Quinn, and J. Mceachen, "World Change the World".
[45] J. Cosgrove and F. Cartwright, "Changes in achievement on PISA: the case of Ireland and implications for international assessment practice," Large-Scale Assessments Educ., vol. 2, no. 1, pp. 1–17, 2014, doi: 10.1186/2196-0739-2-2.