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Characterization of the five-tier model of creative mathematical thinking in primary school learners

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Abstract:
Creative mathematical thinking skills among elementary students remain relatively low, largely due to predominantly procedural instruction, highlighting the need to examine the characteristics of their innovative thinking stages in solving data processing problems using the Subanji five-stage model. The study aimed to identify and describe students' creative thinking patterns in handling ordinal data through the stages of pre-imitation, imitation, modification, combination, and construction. Employing a qualitative case study approach, data were collected from 38 fifth-grade students in Malang through open-ended tasks, think-aloud protocols, interviews, and documentation. The analysis involved data reduction and triangulation. Results revealed the distribution of students across stages: 10.53% at pre-imitation, 34.21% imitation, 23.68% modification, 18.42% combination, and 13.16% construction. Students showed a progression from routine and imitative approaches to independently constructed strategies, such as assigning weighted scores to ranked data and analyzing the frequency of options. These findings suggest that the Subanji model effectively captures the development of creative mathematical thinking and support the integration of open-ended tasks and scaffolded guidance to foster creativity in mathematics learning.

Keywords: Creative Mathematical Thinking; Elementary Students; Open-Ended Tasks; Ordinal Data; Subanji Five-Stage Model.

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Introduction

The ability to think creatively holds a pivotal role in 21st-century mathematics education, particularly at the elementary school level. In an era marked by digital disruption and complex global challenges, students are expected not only to master procedural mathematical concepts but also to develop innovative solutions to contextual and unstructured problems (Clark, 2024; Iamcham & Chanchusakun, 2024). However, according to the 2022 PISA results, Indonesian students' performance in mathematics remains below the OECD average, with a mean score of 366 compared with the OECD average of 472 (OECD, 2023). Similarly, the 2019 TIMSS results place Indonesian fourth-grade students at the 45th position out of 58 participating countries (Mullis et al., 2020). These statistics reflect a significant deficiency in higher-order thinking skills, including creative thinking, and underscore the urgent need to foster such abilities from an early age.

Creative thinking in mathematics functions not only as an indicator of individual cognitive capacity but also as a determinant of students' preparedness for real-world problem solving (Ndiung & Menggo, 2024; Rundquist et al., 2024; Syolendra & Laksono, 2019). When students are trained to think flexibly, originally, and to generate multiple solutions for mathematical problems, they are better equipped to navigate everyday situations. Nevertheless, Shaw et al. (2022) found that only about 20% of elementary students could demonstrate high performance in mathematical tasks requiring creativity, such as open-ended problem solving. In Indonesia, studies by Fathoni & Haryani (2018) as well as Ndiung & Menggo (2024) reveal that although the average creative thinking score among students is moderate (71.6 out of 100), only approximately 4% fall into the "high" category. This outcome suggests that most instructional strategies at the elementary level remain focused on memorization and algorithmic routines rather than exploration and reflective thinking. If this trend continues, it may severely hinder students' cognitive development (Prayitno & Widayanti, 2020, 2024).

Several researchers have attempted to address this issue through various pedagogical models. Syolendra & Laksono (2019) reported that the inquiry training model effectively enhances fluency and flexibility in students' mathematical creative thinking. Daiana et al. (2021), who employed an open geometry approach to assess originality, noted that students frequently replicated their teachers' strategies instead of creating their own. Hill et al. (2008) emphasized the importance of discovery learning in developing both understanding and creativity. Nonetheless, these approaches often lack a clearly defined, systematic framework for the development of creative thinking stages. This gap is addressed by Subanji et al. (2023), who proposed a five-stage model of creative thinking: pre-imitation, imitation, modification, combination, and construction. Although this model has been tested at the secondary level in the context of controversial mathematical problems, its empirical application in elementary education, particularly in data handling topics, remains limited.

The creative thinking model developed by Subanji et al. (2023) presents a compelling framework by mapping students' cognitive progress from the initial pre-imitation stage to the highest construction stage. It emphasizes that creative mathematical thinking is not an innate trait but a developmental process shaped by learning experiences, classroom environments, and teacher scaffolding. In the context of data handling at the elementary level, skills such as reading, interpreting, and presenting data in innovative ways provide tangible applications of this model. For instance, students may be tasked with representing classroom survey results through unique and meaningful graphical formats. However, the integration of the Subanji model into elementary mathematics instruction has yet to be widely explored.

This study aims to identify the characteristics of creative thinking among elementary school students in solving mathematical problems, analyze the stages of innovative thinking based on Subanji et al. (2023) framework, and describe its implementation in the context of data handling. The findings of this research are expected to contribute significantly to the empirical foundation of the creative thinking model and assist teachers in designing more contextual and innovative mathematics instruction. Moreover, the study seeks to reinforce the theoretical basis of mathematics education and inform curriculum development and teacher training. Thus, the significance of this research lies not only in its academic contribution but also in its practical impact on improving the quality of elementary mathematics education.

Research Methods

The present study employed a qualitative approach with an exploratory case study design to investigate in depth the characteristics of elementary students' creative thinking in solving mathematical problems related to data processing. The research involved 38 fifth-grade students from a public elementary school in Malang, Indonesia. Participants were selected purposively, taking into account the diversity of students' mathematical abilities and recommendations from classroom teachers. This strategy ensured a representative and authentic range of thinking strategies for analysis.

Data collection was conducted through direct observation while students worked on open-ended tasks specifically designed to stimulate creative thinking. To capture students' cognitive processes, the think-aloud protocol was utilized alongside semi-structured interviews that provided further insight into their reasoning and alternative strategies. The primary instrument in this study was a data-processing task featuring ordinal data derived from a customer satisfaction survey on a food delivery service. The task required students to interpret ordinal rankings, formulate problem-solving strategies, and justify their conclusions with logical arguments. This task design enabled researchers to map students' responses across five stages of creative thinking as defined by Subanji: pre-imitation, imitation, modification, combination, and construction.

The instrument, illustrated in Picture 1, presented the following scenario: A fast-food restaurant named "MyD" conducted interviews with 10 customers to determine the most influential factors in their decision to use the delivery service. Each customer ranked five reasons: food quality, delivery speed, app convenience, delivery fee, and discounts. Students were tasked with determining the overall priority order of these reasons based on customer rankings and explaining their reasoning.

Data analysis followed Creswell's (2009) interactive model, and trustworthiness was ensured through data reduction, data display, and conclusion drawing. Categorization was guided by key indicators of creative thinking: fluency, flexibility, originality, and elaboration, as well as Subanji's stage-based model. Data validity was ensured through triangulation of techniques (observation, interview, and documentation) and member checks involving both students and teachers. Credibility was further strengthened through peer debriefing with fellow mathematics education researchers.

Fast food restaurant "MyD" provides a food delivery service.
They interviewed 10 customers to identify the main reasons why customers choose to order food using this service. Each customer ranked several factors based on their importance in influencing their decision to use the service.

The table below shows the rankings provided by the customers.

Customer	Food Quality	Delivery Speed	App Convenience	Delivery Fee	Discount
Customer 1	2	1	4	3	5
Customer 2	1	2	3	5	4
Customer 3	3	4	1	2	5
Customer 4	2	1	3	5	4
Customer 5	4	3	2	1	5
Customer 6	1	4	5	2	3
Customer 7	2	3	1	4	5
Customer 8	3	2	1	5	4
Customer 9	1	4	3	2	5
Customer 10	2	1	4	3	5

Question:
Based on the data above, rank the reasons customers choose the food delivery service from most important to least important. Explain your answer!

Picture 1. The Instrument Used in This Research

Results and Discussions

The distribution of elementary school students' creative thinking stages in solving data processing problems is presented in Table 1.

Table 1. The Distribution of Students' Creative Thinking Stages

Stage of Creative Thinking	Number of Students	Percentage (%)
Pre-imitation	4	10.53%
Imitation	13	34.21%
Modification	9	23.68%
Combination	7	18.42%
Construction	5	13.16%
Total	**38**	**100%**

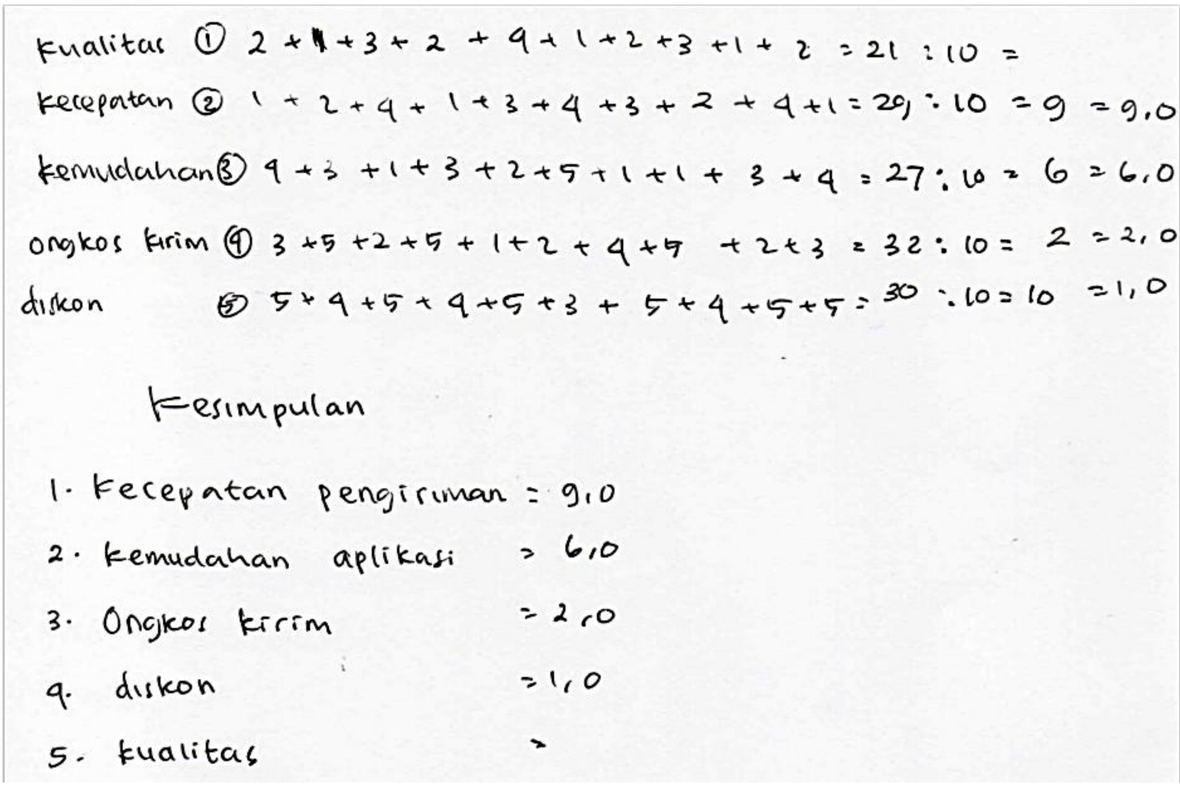
The data reveal that the majority of students (34.21%) are situated at the imitation stage, where problem-solving is achieved primarily by replicating previously demonstrated strategies without significant adaptation. This predominance suggests that students' learning experiences remain largely procedural, offering limited opportunities for the development of innovative or exploratory thinking.

However, there are indications of progression toward more advanced forms of creative mathematical thinking. Approximately 23.68% of students have reached the modification stage, characterized by the ability to adapt learned strategies to the specific demands of a problem. It reflects a growing capacity for flexible thinking. Moreover, 18.42% of students demonstrate combination skills, involving the integration of two or more strategies to arrive at more effective solutions. These stages signal an emerging initiative and adaptability in mathematical reasoning, marking a shift from rote application to more dynamic cognitive engagement.

A smaller proportion of students (13.16%) have attained the construction stage, which entails the independent development of novel problem-solving strategies. Although this group is relatively limited in number, their presence is significant, as it indicates the potential for reflective and innovative thinking. Facilitating and nurturing this potential is essential for fostering higher-order cognitive skills in mathematics education. Conversely, 10.53% of students remain at the pre-imitation stage, in which they are able to comprehend the problem context but have not yet developed the capacity to formulate a viable solution strategy. This group requires targeted support to bridge the gap toward more strategic and autonomous problem-solving behavior.

The Pre-Imitation Stage in Elementary Students' Creative Thinking

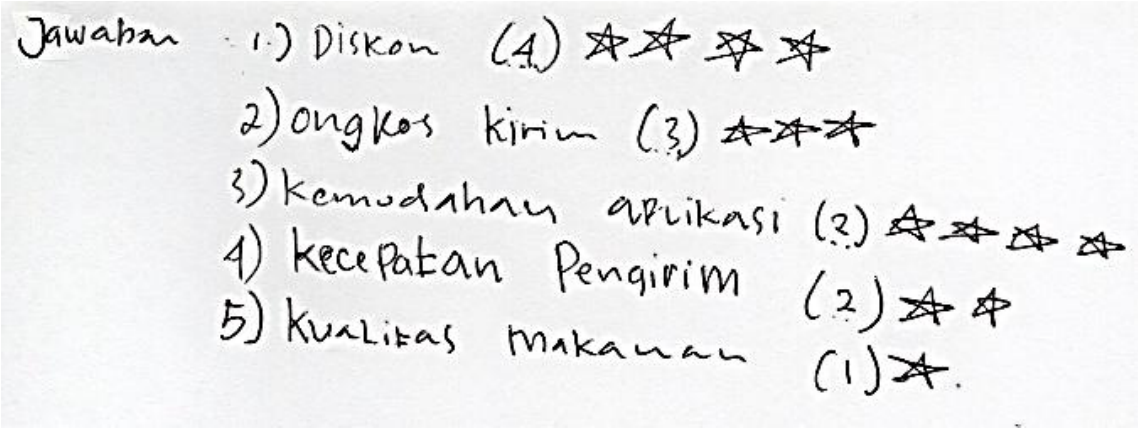
At the pre-imitation stage, students' creative thinking is characterized by a very early level of cognitive engagement. At this point, students may recognize the presence of information in a problem, but they cannot construct relevant solution strategies. Typically, students in this phase are able to identify basic elements such as data categories and table structures. However, they struggle to integrate these components into coherent logical reasoning that leads to valid problem-solving steps. Their thought processes often lack direction, break down mid-task, or culminate in conclusions that are inconsistent with the available data.


Kualitas ① 2 + 1 + 3 + 2 + 9 + 1 + 2 + 3 + 1 + 2 = 21 : 10 =
Kecepatan ② 1 + 2 + 9 + 1 + 3 + 4 + 3 + 2 + 4 + 1 = 29 : 10 = 9 = 9,0
Kemudahan ③ 9 + 3 + 1 + 3 + 2 + 5 + 1 + 1 + 3 + 9 = 27 : 10 = 6 = 6,0
ongkos kirim ④ 3 + 5 + 2 + 5 + 1 + 2 + 9 + 5 + 2 + 3 = 32 : 10 = 2 = 2,0
diskon ⑤ 5 + 9 + 5 + 9 + 5 + 3 + 5 + 9 + 5 + 5 = 30 : 10 = 10 = 1,0

Kesimpulan

1. Kecepatan pengiriman = 9,0
2. kemudahan aplikasi = 6,0
3. Ongkos kirim = 2,0
9. diskon = 1,0
5. kualitas =

The answer to S1



The answer to S2

Picture 2. The S1 and S2 answer in the pre-imitation stage

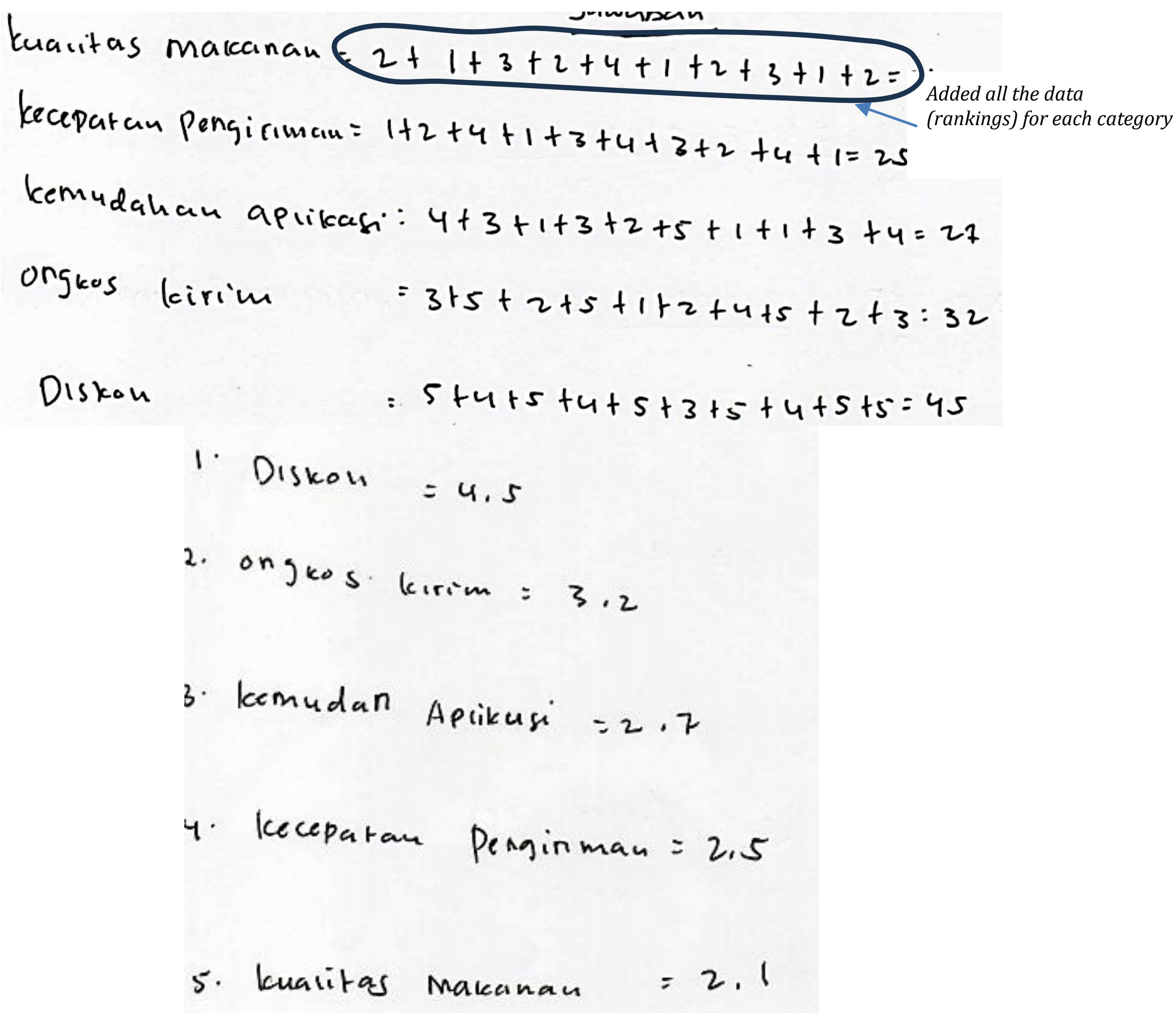
For instance, one Student 1 (S1), demonstrated an ability to read the data table and sum numerical values in each column. However, these calculations were not meaningfully integrated into any reasoning process. Moreover, logical errors were apparent, such as reporting an average discount of 1.0 and a food quality rating of 0, both of which were inconsistent with the actual data. It reflects a fundamental misunderstanding of basic concepts, such as the interpretation of ordinal data and the correct calculation of averages. Furthermore, there was no indication of any reflective effort to evaluate or revise these inaccuracies, suggesting an absence of foundational metacognitive skills.

Another Student 2 (S2) attempted to count the frequency of the highest rankings (indicated by the number 1, marked with stars), but did not progress to comparative analysis or the formulation of conclusions. Upon realizing the limitations of their approach, the student merely expressed uncertainty ("Is this the correct method?"). Yet made no evident attempt to explore alternative strategies. While this reveals an initial form of metacognitive awareness, it was not accompanied by the ability to adapt or reconstruct their problem-solving approach.

Thus, the pre-imitation stage is marked by a passive recognition of problems without active engagement in information processing. Instructional interventions at this stage should emphasize intensive scaffolding, explicit modeling of problem-solving strategies, and the provision of meaningful experiences in data interpretation and analysis. These efforts aim to help students overcome initial cognitive barriers and progress toward the imitation stage, where foundational strategic thinking necessary for creative problem-solving begins to emerge.

Imitation Stage in Elementary Students' Creative Thinking

At the imitation stage, elementary students' creative thinking is characterized by the ability to reproduce previously taught problem-solving strategies without making contextual adaptations or modifications. Students at this level typically demonstrate mastery of basic procedural tasks such as performing addition, ordering numerical data, or selecting types of data representations, yet lack a deeper conceptual understanding of data structures, the contextual meaning of problems, or the ultimate goals of the analysis. This stage reflects a reliance on memorized procedures rather than thoughtful engagement with the task at hand.



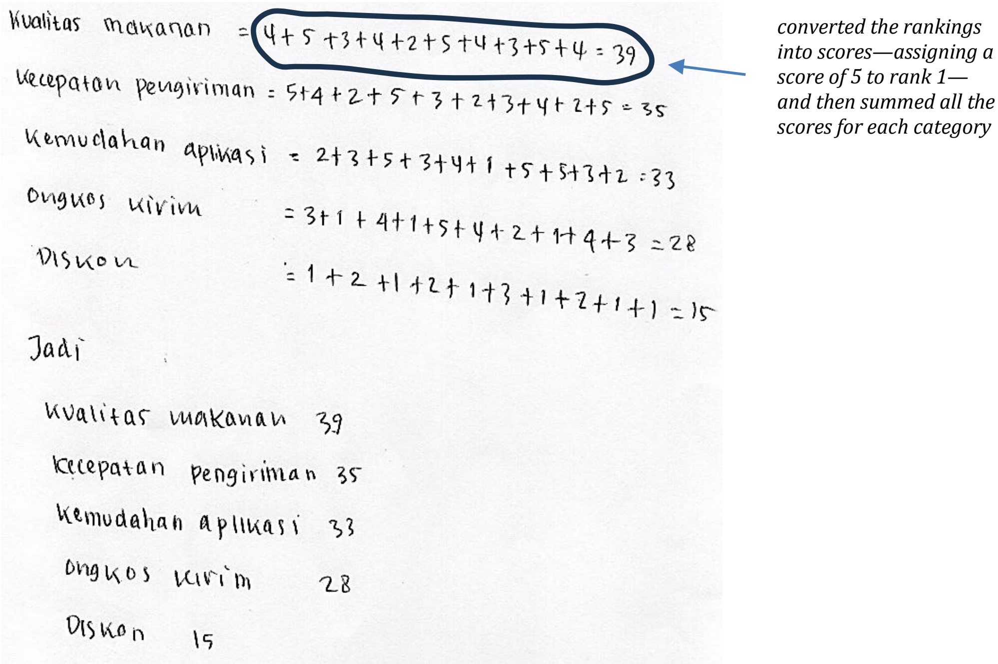
Picture 3. The S3 answer in the imitation stage

This phenomenon is clearly illustrated in the think-aloud data of Student 3 (S3) during a data-processing task. For instance, the student began by stating, *"Okay, I'll start by adding up all the values for each reason,"* and proceeded to vocalize the data: *"Food quality: 2 plus 1 plus 3... that makes 21."* The same procedure was repeated across categories, and the student concluded by ranking the categories based on the smallest total values, without questioning the ordinal nature of the data or the appropriateness of such a quantitative approach. Statements like, *"This is like the practice in the book,"* or *"This is how the teacher taught us yesterday,"* indicate that the strategy was derived from prior learning experiences, not from independent reasoning or contextual adaptation.

Although students at this stage exhibit logical structure and procedural consistency as reflected in remarks such as, "Now I'll sort them from the smallest to the largest," their thinking remains closed-ended. They follow linear steps without exploring alternative strategies or engaging in critical reflection. Notably absent is any evaluation of the methodological validity (e.g., whether it is appropriate to sum ordinal data) or consideration of the alignment between the procedures used and the context of the problem. These limitations highlight a lack of flexibility and originality two core components of creative thinking.

Modification Stage in Elementary Students' Creative Thinking

The modification stage signifies a notable shift in the development of students' creative thinking, marked by their growing ability to adapt previously learned problem-solving strategies. At this stage, students no longer follow procedures in a purely mechanical manner; instead, they begin to demonstrate initiative by modifying conventional approaches to improve the relevance, accuracy, or efficiency of their solutions. A defining characteristic of this stage is the emergence of cognitive flexibility and an awareness of the limitations inherent in standard strategies.



Picture 4. The S4 answer in the modification stage

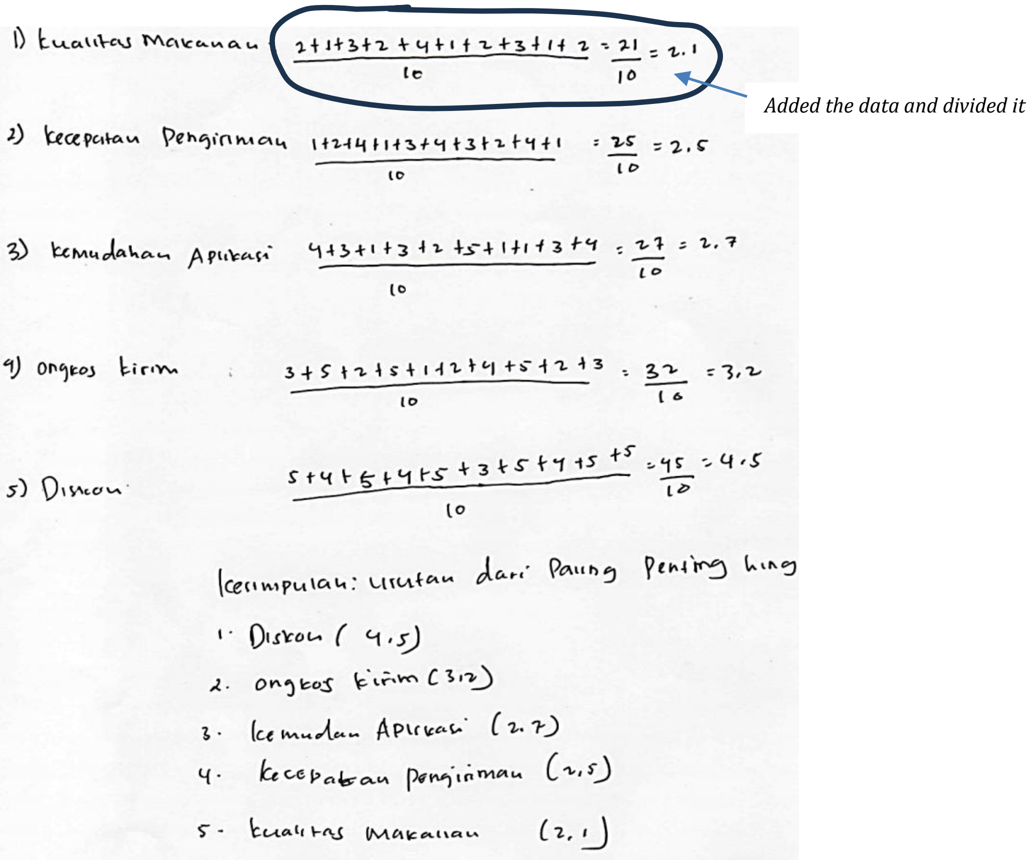
In the context of data processing, Students 4 (S4) operating at the modification stage begin to construct personal interpretations of data structures, particularly ordinal data. A salient example from this study involved a student who opted not to sum values but instead developed a weighted scoring system. During a think-aloud session, the student explained, *"If all the values are added up, the result could be misleading. The lower numbers are actually more important. Thus, I assigned scores: value 1 gets 5 points, value 2 gets 4 points, and so on until value 5 gets 1 point."* This statement reflects an understanding that the numbers represent an ordinal sequence, indicating priority rather than absolute quantity.

Furthermore, the student integrated this scoring system into their analytical strategy by calculating the total points for each category and comparing them. The explanation, *"It's not just about the total numbers; the important ones get a higher weight,"* indicates a shift toward conceptual and contextual reasoning. This student demonstrated an ability to interpret the underlying meaning of the data, rather than relying solely on surface-level representations.

Overall, the modification stage represents the early emergence of independent creative thinking, as students engage in exploratory efforts to tailor strategies to the characteristics of the problem at hand. The think-aloud results reveal reflective and logical reasoning, indicative of metacognitive activity essential for informed decision-making. At this stage, students begin to move beyond imitation and develop a foundational conceptual understanding of open-ended and complex problems.

The Combination Stage in Elementary Students' Creative Thinking

The combination stage reflects an advanced level of cognitive development in students' creative thinking, characterized by their ability to integrate two or more problem-solving strategies previously learned. Rather than relying on a single, fixed approach, students at this stage demonstrate cognitive flexibility by synergistically synthesizing multiple methods to produce more accurate and meaningful solutions.



Picture 5. The S5 answer in the combination stage

In the context of data processing, one identified form of strategic combination involves merging the addition of values within each customer reason category with division by the total number of customers to calculate an average. This approach indicates Student 5 (S5) awareness of the need to adjust total values according to differing data scales, thus generating more representative information. As one student expressed, *"First, I added all the values, then divided them by the number of customers to find the average score."*

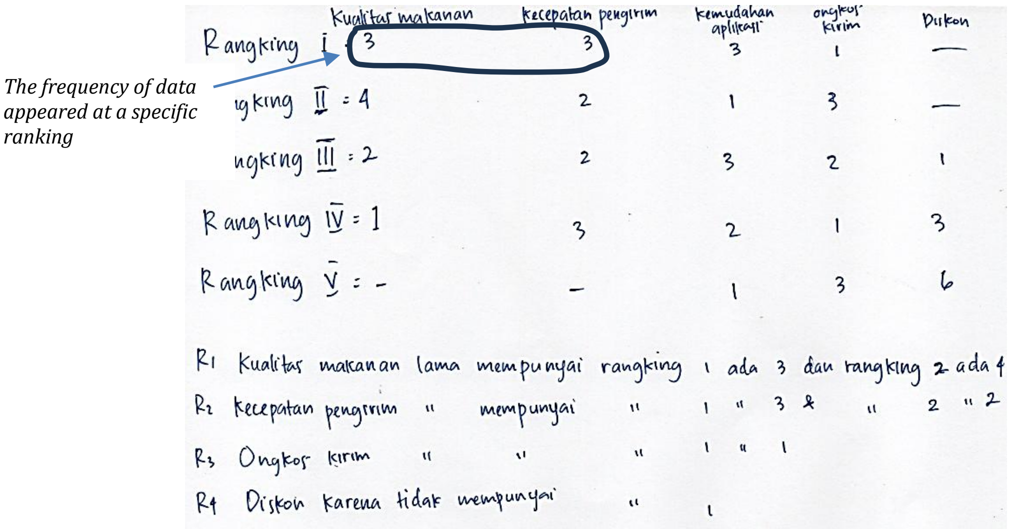
Such verbalizations reflect a complex, reflective thought process. The student not only aggregates data but also applies normalization techniques to balance the data in relation to sample size. It reveals a more sophisticated form of analytical thinking, wherein students consciously formulate an integrated procedure to produce solutions that are both fair and precise.

The combination stage signifies cognitive maturity, as students do not merely modify a single strategy but construct a sequence of complementary strategies informed by their understanding of the problem context. By integrating basic quantitative calculations (addition) with rationalization through division (averaging), students exhibit the ability to synthesize data and evaluate outcomes critically.

This stage marks a shift from linear thinking to multi-layered reasoning, characterized by openness to diverse strategic pathways. Instructional practices that encourage exploration of various approaches, along with opportunities to compare the effectiveness of different strategies within complex contexts, are essential in fostering the emergence of this stage in students' creative thinking processes.

The Construction Stage in Elementary Students' Creative Thinking

The construction stage represents the highest level in the hierarchy of creative thinking, characterized by a student's ability to independently design original and contextually appropriate problem-solving strategies based on a deep conceptual understanding. At this stage, students are no longer reliant on previously taught methods; instead, they construct novel approaches tailored to the nature of the data and the contextual demands of the task.



Picture 6. The S6 answer in the construction stage

In the context of a data analysis task themed around "restaurant issues," Student 6 (S6) operating at the construction level demonstrated a deliberate departure from conventional numerical strategies, such as simple summation, commonly observed in earlier stages like imitation or modification. Rather than aggregating values, one student formulated a method grounded in the understanding that the data were ordinal in nature, where the value '1' indicated the highest level of importance. The student prioritized analyzing the frequency of '1' across different categories as the primary indicator of priority, consciously choosing to disregard standard numerical procedures that were incongruent with the data characteristics.

Moreover, the student enhanced the analysis by incorporating the frequencies of values '2' and '3' to reinforce the validity of the conclusions. This process was accompanied by reflective reasoning, as evidenced by the student's think-aloud statement: "Since the number 1 means most important, I count how many times each reason gets a 1. But to be more accurate, I also look at 2s and 3s. So it's not just from one angle." It illustrates key indicators of creative thinking, such as *elaboration* and *flexibility*, reflecting the ability to broaden analytical perspectives and adapt strategies to suit interpretive needs.

The student also displayed critical awareness of conventional methods, identifying limitations in summing ordinal data: "If we just add the numbers, then those with low values but frequently ranked first might appear less important." This insight demonstrates *originality* in thinking and reveals a more substantive grasp of statistical principles beyond procedural application.

Overall, the student's strategy in the construction stage was not a reproduction of prior knowledge but a personal construction based on the interpretation of data and contextual understanding. This approach reflects the divergent thinking, conceptual synthesis, and independent logical reasoning hallmarks of advanced creative thinking. As such, students at this stage can be classified as reflective and innovative problem-solvers, capable of developing meaningful and original solutions autonomously.

Discussion

The findings of this study reveal that elementary school students' creative thinking abilities in solving data processing problems develop progressively across five cognitive levels: pre-imitation, imitation, modification, combination, and construction. The majority of students were found to be at the imitation stage (34.21%), followed by modification (23.68%), combination (18.42%), construction (13.16%), and pre-imitation (10.53%). These results confirm that creative thinking is not an innate or instantaneous skill, but rather a gradual developmental process situated within a complex continuum. This progression necessitates systematic and reflective instructional support to facilitate students' transition from procedural strategies toward more innovative approaches.

The distribution of stages suggests that most students still rely on replicating taught strategies without contextual adaptation. However, the presence of students at the modification, combination, and construction levels indicates the emerging potential of mathematical creativity. These findings support the theory that creative mathematical thinking encompasses dimensions such as fluency, flexibility, originality, and elaboration (Koparan et al., 2023; Shaw et al., 2022; Syolendra & Laksono, 2019). Specifically, students at the modification stage exhibited flexibility by developing weighting systems for ordinal data; those at the combination stage demonstrated the integration of quantitative and normative approaches; while students at the construction stage displayed the capacity to formulate entirely new strategies beyond those explicitly taught.

When compared with previous research, these findings are consistent with studies by Atmaja et al. (2023) and Subanji et al. (2023), which proposed and validated a five-stage model of creative thinking. The characteristics of students at each stage in the current study align with Subanji cognitive indicators from unreflective mimicry at the imitation stage to strategic synthesis at the combination and construction stages. Similarly, these results reinforce Syolendra & Laksono (2019) emphasis on the value of discovery learning in fostering creativity through self-guided exploration. Fathoni et al. (2018) likewise highlighted the efficacy of inquiry-based training in enhancing students' cognitive flexibility and fluency. However, this study extends those contributions by applying the five-stage model systematically within the specific context of ordinal data processing. This area has been underexplored in empirical research, thereby enhancing the external validity of the Subanji model.

Interestingly, the findings diverge from Subanji et al. (2023), who reported a higher concentration of students at the modification and construction stages (each exceeding 30%). This discrepancy may be attributed to differences in task context, instructional background, and students' prior exposure to non-routine problems. As such, this study provides a novel contribution by adapting the creative thinking model to the context of ordinal data in primary education, which enhances our understanding of its applicability across domains.

Theoretically, the findings strengthen the relevance of the five-stage model as a diagnostic tool for mapping students' creative thinking development. The model not only captures the dynamic nature of students' thought processes but also underscores the necessity for instructional interventions tailored to each developmental level. Practically, educators are encouraged to design open-ended, challenging mathematical tasks and to provide appropriate scaffolding to support students' progression to higher stages. Furthermore, the model holds potential for integration into formative assessment practices, allowing teachers to monitor and guide students' cognitive growth continuously.

From a policy perspective, the results advocate for the integration of creative thinking competencies into the elementary mathematics curriculum, particularly within the domain of data processing. Curricula should emphasize not only the outcomes but also the cognitive processes involved. Instructional strategies such as lesson study, open-ended learning, and authentic assessment are well-suited to cultivating a classroom culture that values creative thinking (Clark, 2024; Gavrilović, 2023).

An unexpected finding emerged regarding the relatively low proportion of students at the construction stage, despite the provision of open-ended and contextual tasks. It suggests that students may not yet be accustomed to problems that require divergent thinking, or that teachers may not be fully optimizing exploratory scaffolding practices. Alternatively, the development of creative thinking may require extended time and experience. This interpretation is supported by Shaw et al. (2022), who found that the incorporation of incubation periods significantly enhances students' creative performance.

Conclusions and Suggestions

This study reveals that elementary students' creative thinking abilities in solving data processing problems progress through five cognitive stages: pre-imitation, imitation, modification, combination, and construction. At the *pre-imitation*, students recognize and manipulate numerical data but demonstrate limited understanding of the relationships among the data, often performing calculations without meaningful interpretation. During the *imitation*, students reproduce procedures previously shown by the teacher without critically evaluating their appropriateness for the context, indicating reliance on procedural strategies. In the *modification*, students begin to adapt existing techniques to the contextual demands of the problem, such as assigning different weights to ordinal data, reflecting emerging initiative and flexibility. The *combination* involves integrating multiple strategies to achieve more coherent and meaningful outcomes. At the same time, the *construction* reflects the highest level of creativity, with students independently generating novel strategies based on a conceptual understanding of the data structure, such as developing frequency-based approaches to prioritize customer categories. The majority of students were found at the imitation stage, highlighting a general dependence on procedural methods. Yet, the presence of students operating at the modification through construction levels signals the emergence of mathematical creativity. This research extends the application of the Subanji model to the context of ordinal data at the elementary level, thereby enriching the theoretical framework surrounding creative thinking processes. Practically, the findings underscore the importance of open-ended tasks, systematic scaffolding, and process-based formative assessment as effective instructional strategies to foster innovative thinking development. Furthermore, this study contributes to curriculum policy by advocating for the integration of creative thinking skills into basic competency standards, particularly within data processing topics.

Future research is recommended to design and test structured learning interventions, such as open-ended data processing tasks with gradual scaffolding, to support students in progressing from the imitation stage to modification, combination, and construction stages. Additionally, the use of interactive digital media or visual aids can be explored to enhance students' understanding of ordinal concepts and facilitate the independent development of novel problem-solving strategies. Future studies could also develop process-based formative assessment instruments to operationally monitor the development of students' creative thinking and apply the five-stage creativity model to other mathematics topics, such as word problems, geometry, or fractions, to examine the model's consistency and the effectiveness of instructional strategies across different contexts.

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References

Atmaja, S. A. A., Nusantara, T., & Subanji, S. (2023). Berpikir kreatif siswa dalam menyelesaikan permasalahan kontroversial matematis [Students' creative thinking in solving controversial mathematical problems]. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 1240. https://doi.org/10.24127/ajpm.v12i1.6764

Clark, Q. M. (2024). A pedagogical approach: toward leveraging mathematical modeling and AI to support integrating humanities into STEM education. *Frontiers in Education*, *9*, 1396104. https://doi.org/10.3389/FEDUC.2024.1396104/BIBTEX

Creswell, J. W. (2009). *Research design qualitative, quantitative, and mixed approaches* (3rd ed). SAGE.

Daiana, P., Surahmat, S., & Fathani, A. H. (2021). Profile of students' mathematical creative thinking ability in solving mathematical problem. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *11*(1), 49–62. https://doi.org/10.30998/formatif.v11i1.7810

Gavrilović, B. (2023). Mathematical modeling in teaching using data analytics. *Norma*. https://doi.org/10.5937/norma2301079g

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking Pedagogical Content Knowledge: Conceptualizing and Measuring Teachers' Topic-Specific Knowledge of Students. *Journal for Research in Mathematics Education*, *39*(4), 372–400. https://doi.org/10.5951/jresematheduc.39.4.0372

Iamcham, N., & Chanchusakun, S. (2024). The effect of the mathematics instruction model on enhancing mathematical thinking. *International Journal of Evaluation and Research in Education (IJERE)*, *13*(5), 3130–3138. https://doi.org/10.11591/IJERE.V13I5.29609

Koparan, T., Dinar, H., Koparan, E. T., & Haldan, Z. S. (2023). Integrating augmented reality into mathematics teaching and learning and examining its effectiveness. *Thinking Skills and Creativity*, *47*, 101245. https://doi.org/10.1016/J.TSC.2023.101245

Fathoni, I. M., Isnarto, & Haryani, S. (2018). Mathematically creative thinking abilities students of elementary school on learning inquiry training based on learningstyle article info. *Journal of Primary Education JPE*, *7*(2), 121–128. https://journal.unnes.ac.id/sju/index.php/jpe/article/view/23160

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., Fishbein, B., & Pirls, T. &. (2020). *International results in mathematics and science timss & pirls*. TIMSS & PIRLS International Study Center, Boston College.

Ndiung, S., & Menggo, S. (2024). Project-based learning in fostering creative thinking and mathematical problem-solving skills: evidence from primary education in indonesia. *International Journal of Learning, Teaching and Educational Research*, *23*(8), 289–308. https://doi.org/10.26803/ijlter.23.8.15

OECD. (2023). Pisa 2022 Results. In *Factsheets: Vol. I*. 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/

Prayitno, A., & Widayanti, F. D. (2020). Identification of student thinking error patterns in construction of mathematical proof. *Üniversitepark Bülten*, *9*(1), 7–14. https://doi.org/10.22521/unibulletin.2020.91.1

Prayitno, A., & Widayanti, F. D. (2024). Unveiling students' refractive thinking process who use a single strategy in decision making. *Edumatika : Jurnal Riset Pendidikan Matematika*, *7*(2). https://doi.org/10.32939/EJRPM.V7I2.3868

Rundquist, R., Holmberg, K., Rack, J., Mohseni, Z., & Masiello, I. (2024). Use of learning analytics in K–12 mathematics education: systematic scoping review of the impact on teaching and learning. *Journal of Learning Analytics*, *11*(3), 174–191. https://doi.org/10.18608/jla.2024.8299

Shaw, S. T., Luna, M. L., Rodriguez, B., Yeh, J., Villalta, N., & Ramirez, G. (2022). Mathematical creativity in elementary school children: general patterns and effects of an incubation break. *Frontiers in Education*, *7*(March), 1–8. https://doi.org/10.3389/feduc.2022.835911

Subanji, Nusantara, T., Sukoriyanto, & Atmaja, S. A. A. (2023). Student's creative model in solving mathematics controversial problems. *Cakrawala Pendidikan*, *42*(2), 310–326. https://doi.org/10.21831/cp.v42i2.55979

Syolendra, D. F., & Laksono, E. W. (2019). The effect of discovery learning on students' integrated thinking abilities and creative attitudes. *Journal of Physics: Conference Series*, *1156*(1). https://doi.org/10.1088/1742-6596/1156/1/012018