JPM
Jurnal Pendidikan Matematika
UNIVERSITAS ISLAM MALANG

ARTICLE INFORMATION

Mathematical creative thinking profiles of sanguine students in solving open-ended social arithmetic problems

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How to cite (APA Style):
Sari, A. K., Rohim, A., & Aini, K. N. (2026). Mathematical creative thinking profiles of sanguine students in solving open-ended social arithmetic problems. *Jurnal Pendidikan Matematika (JPM)*, *12*(2), 133-146. https://doi.org/10.33474/jpm.v12i2.25821

DOI	https://doi.org/10.33474/jpm.v12i2.25821
Contributions	**Ajeng Kurnia Sari**: CCP, MTD, INV, DAC, ANL, WOD, WRE. **Abdur Rohim**: CCP, MTD, SPV, WRE. **Khafidhoh Nurul Aini**: DAC, ANL, SPV, WRE.
Funding	This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.
Conflict of Interest	The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.
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*** CRediT roles:** CCP: Conceptualization; MTD: Methodology; INV: Investigation; DAC: Data Curation; ANL: Formal Analysis; WOD: Writing - Original Draft; WRE: Writing - Review & Editing; SPV: Supervision.

JURNAL PENDIDIKAN MATEMATIKA (JPM)
Vol. 12, No. 2, 2026, pp 133–147 e-ISSN: 2656–4564
https://doi.org/10.33474/jpm.v12i2.25821
online at: https://riset.unisma.ac.id/index.php/jpm/article/view/25821/

MATHEMATICAL CREATIVE THINKING PROFILES OF SANGUINE STUDENTS IN SOLVING OPEN-ENDED SOCIAL ARITHMETIC PROBLEMS

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ABSTRACT

Creative thinking is an essential competency in 21st-century mathematics education. However, observations and interviews with mathematics teachers at MTs Nurul Jadid Banjarmadu (Islamic Junior High School) revealed that students still have difficulty solving open-ended problems that require diverse strategies and the development of creative ideas. Although personality type is known to influence creativity, studies examining the creative thinking profiles of sanguine students when solving open-ended social arithmetic problems remain limited. This study employed a descriptive qualitative approach using the interactive analysis model. The subjects were two sanguine-type students (S-1 and S-2) selected from 26 seventh-grade students through the Florence Littauer personality questionnaire. Data were collected through social arithmetic open-ended tests and semi-structured interviews, and then analyzed using four creative thinking indicators: fluency, flexibility, originality, and elaboration. Method triangulation was conducted by comparing the participants' written responses with their interview explanations. The results showed that sanguine students met the fluency indicator by providing four valid answer pairs and the flexibility indicator by applying two different solution strategies. However, neither subject showed originality, using common strategies, and neither showed elaboration, due to lack of full verification of solution steps. The patterns observed in both participants suggest that the generation of many ideas, the presence of spontaneity and enthusiasm can be trained, and that the restriction to verification and detailed explanation can act as a barrier to the elaboration of ideas when dealing with a mathematical problem. Therefore, teachers are suggested to offer structured verification activities and guided solution frameworks to enhance originality and elaboration, while maintaining fluency and flexibility.

Keywords: Mathematical Creative Thinking, Open-Ended Problems, Sanguine Personality, Social Arithmetic, Qualitative Case Study.

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Submission	Revised	Accepted	Published
June 26, 2026	July 27, 2026	August 6, 2026	August 24, 2026

How to cite (in APA style):
Sari, A. K., Rohim, A., & Aini, K. N. (2026). Mathematical creative thinking profiles of sanguine students in solving open-ended social arithmetic problems. *Jurnal Pendidikan Matematika (JPM)*, *12*(2), 133–146. https://doi.org/10.33474/jpm.v12i2.25821

INTRODUCTION

Mathematics is a field of study that has a significant impact on everyday life and functions to develop students' critical thinking, creativity, and problem-solving skills (Anita et al., 2024; Rohim & Prayogi, 2023). Creative thinking ability has become one of the 21st-century competencies that need to be developed in mathematics learning (Rohim et al., 2023, 2025). The importance of this skill is also emphasized through the Minimum Competency Assessment (AKM), which seeks to enhance skills in critical thinking, creativity, problem-solving,

communication, and teamwork (Rohim & Rofiki, 2024). Additionally, communicative, creative, and innovative mathematics learning can increase students' participation and academic achievement by creating more engaging learning experiences and reducing learning anxiety (Rohmah et al., 2024).

The implementation of mathematics learning in classrooms has not yet optimally facilitated the development of students' creative thinking skills. Preliminary observations and interviews conducted with seventh-grade mathematics teachers at Islamic Junior High School (MTs) Nurul Jadid Banjarmadu revealed that many students still struggle to solve open-ended mathematical problems that require various solution approaches. In addition, students often have difficulty explaining the reasoning and procedures underlying their answers comprehensively. These findings suggest that students' mathematical creative thinking skills have not been sufficiently developed and therefore require further improvement. The level of students' mathematical ability is also affected by differences in their backgrounds, individual characteristics, and previous learning experiences, which contribute to variations in their performance and problem-solving strategies (Rohim & Wayiya, 2022). Additionally, limitations in utilizing information and low accuracy can hinder the emergence of creative mathematical ideas (Pratiwi et al., 2021). Typically, students can address factual and procedural challenges; however, they often find it difficult to tackle non-routine problems that require advanced thinking abilities (Maulana et al., 2021; Mustofah et al., 2020). As a result, enhancing the creative mathematical thinking abilities of students continues to be a key emphasis in education.

The ability to think creatively in mathematics includes four indicators proposed by Munandar (1987), namely fluency, which shows the ability to produce many correct answers; flexibility, which demonstrates the ability to use various problem-solving strategies; originality, which indicates the ability to generate unique or unusual solutions; and elaboration, which reflects the ability to develop solutions in detail and systematically. This idea is in accordance with Guilford's (1967) theory of divergent thinking encompassing fluency, flexibility, originality, elaboration, and sensitivity as the core dimensions of creativity and with the later development of the Torrance Tests of Creative Thinking (TTCT) by Torrance (1974). These conceptual foundations are still valid today within the framework of mathematics education, where mathematical creativity is defined in terms of students' ability to produce various ideas, use different solution strategies, and generate original mathematical reasoning (Bruhn & Lüken, 2023). Johar et al. (2023) define it as the ability to analyze and combine information to solve problems, while Sipahi & Bahar (2025) emphasizes that this ability enables students to solve problems accurately through a unique approach.

The use of open-ended questions is considered effective for measuring and developing students' creative thinking abilities because it allows for multiple answers or solution strategies (Dewi & Juandi, 2023). The use of open-ended questions can also help students achieve indicators of creative thinking and reveal the variety of their creative thinking abilities (Bruhn, 2024; Rahayuningsih et al., 2021). Relevant social arithmetic material is used in open-ended questions because it relates to everyday life contexts, such as profits in buying and selling activities (Friantini et al., 2020). However, students still experience difficulties connecting social arithmetic concepts to real-life situations, especially in open-ended problems, so their ability to generate alternative solutions needs further development (Hartmann et al., 2021).

Besides cognitive aspects, personality traits also play an important role in shaping students' thinking processes and approaches to solving mathematical problems. According to Florence Littauer, personality can be classified into four main types: sanguine, choleric, melancholic, and phlegmatic, each of which exhibits distinct patterns of thinking and problem-solving behaviour (Faiz et al., 2022; Littauer, 1992). It is known that personality types affect students' strategies and creativity in solving open-ended problems (Aini & Hidayah, 2024;

Hidayati et al., 2020). Melancholic students tend to be meticulous and systematic; sanguine students are more flexible but less organized Meier et al., (2024) choleric students tend to make decisions quickly but pay less attention to details, while phlegmatic students exhibit calm and consistent thinking patterns (Nabila et al., 2023). Specifically, sanguine students have spontaneous, enthusiastic, and flexible traits that can encourage the emergence of various ideas, although they may sometimes be less careful and less detailed in their thinking (Littauer, 1992). Therefore, understanding the relationship between personality types and creative mathematical thinking abilities is important for supporting more adaptive learning.

Research on the ability to think creatively in mathematics using open-ended questions has been widely conducted (Pakpahan & Wijayanti, 2025; Rahayuningsih et al., 2021; Vitara et al., 2022), but it has generally not considered students' personality types. Conversely, studies examining mathematical creative thinking from a personality perspective generally compare Florence Littauer's four personality types simultaneously and provide only broad comparisons between personality groups. As a result of solving problems practically nothing is known about how the properties of certain types of personalities are manifested in the different indicators of mathematical creative thinking. There is limited research on sanguine students within the framework of social arithmetic but a closer look at this personality type may provide more insight into the strengths and weaknesses associated with fluency, flexibility, originality and elaboration. This understanding can contribute to the literature on mathematical creative thinking and personality-informed mathematics instruction by helping teachers to design learning activities and support systems that are more responsive to the characteristics of sanguine students. Therefore, this study aims to examine the mathematical creative thinking profile of sanguine students when solving open-ended social arithmetic problems.

Therefore, this study aims to analyze the creative thinking abilities of middle school students with sanguine personality types when solving open-ended problems in social arithmetic material, specifically using indicators of fluency, flexibility, originality, and elaboration as proposed by Munandar (1987). The results of this study are expected to provide a deeper understanding of the relationship between sanguine personality characteristics and mathematical creative thinking abilities, and to inform teachers in designing adaptive and appropriate learning strategies for sanguine students.

METHOD

Research Design

This research uses a qualitative descriptive research design following the data analysis procedures proposed by Miles and Huberman (2013). The study employs this research design to comprehensively describe and interpret the creative thinking processes of students with sanguine personality characteristics. Data were gathered through written assessments and semi-structured interviews, while the researcher did not manipulate any research variables. The collected data are reported as objective narrative descriptions, providing an in-depth portrayal of the participants' conditions and cognitive processes during problem-solving activities.

Research Location and Participants

This study was carried out at Islamic Junior High School (MTs) Nurul Jadid Banjarmadu and involved seventh-grade students as the research participants. The procedure for selection took place in two stages. In the initial stage, every student in seventh grade filled out the Florence Littauer Personality Type Questionnaire to find out their main personality traits. In the following stage, two students recognized as having a primary sanguine personality were selected as participants in the research and given the identifiers S-1 and S-2. The selection was based on recommendations from the mathematics teacher and the fulfillment of several predetermined criteria, including: (1)

willingness to participate in the study, (2) the ability to communicate effectively and explain their reasoning clearly, (3) completion of the creative thinking test, (4) willingness to take part in an in-depth interview, (5) attendance throughout the data collection process, and (6) evidence of at least two out of the four creative thinking indicators proposed by Munandar in their written responses. If the interview findings show that a selected participant has less than two creative thinking indicators, then the participant will be replaced by another student with a sanguine personality who meets all the selection criteria listed.

Instrument

This research employed three instruments which were validated by a lecturer of mathematics and a teacher of mathematics before being used. The first instrument is a Florence Littauer personality type questionnaire that is used to categorize students according to personality type. The questionnaire contains 40 items of statements written in the form of scenarios and four answer choices of four personality types: option A for sanguine, B for choleric, C for melancholy, D for phlegmatic. The student's dominant personality type is determined based on the most frequently chosen answer across all items.

The second instrument is a creative thinking test consisting of one open-ended essay question on social arithmetic material. In this test, students are asked to find as many pairs of selling prices (p, q) that meet the criteria $330p + 20q \geq 750{,}000$, and $q < p$, and to demonstrate more than one solution strategy. The indicators and assessment descriptors used to evaluate students' answers are presented in Table 1.

Table 1. Characteristics of Creative Thinking Indicators in Test Items

No.	Creative Thinking Indicator	Description
1.	Fluency	The student can produce more than one open pair of selling prices (p, q) that satisfy the profit requirement (30p + 20q ≥ 750,000) and the condition q < p, demonstrating the ability to generate multiple possible solutions.
2	Flexibility	Students use more than one problem-solving strategy, such as a two-variable linear inequality approach, proportional profit distribution, discount percentage, or trial-and-error methods, demonstrating a variety of thinking skills.
3	Originality	The student develops a different problem-solving strategy from other students in this study, which is determined after all answers are analyzed and includes the use of mathematical models or uncommon reasoning patterns.
4	Elaboration	Students develop complete, systematic solution steps, including formulating the profit inequality, checking each price pair against the two given conditions, and explaining the reasoning at each stage of the solution.

The third instrument is a semi-structured interview guide used to explore each subject's thought process in more depth. This interview guide is based on four indicators of creative thinking, with supporting questions designed to explore each.

Data Collection

Data collection was carried out in three stages. In the preparation stage, the researcher prepared and validated all research instruments, obtained permission from the school

authorities, and set the research schedule. In the implementation stage, the personality type questionnaires were given to all seventh-grade students to identify their personality types. Then all students completed a social arithmetic test consisting of open-ended questions. Next, two students with sanguine personality types, namely S-1 and S-2, were selected as research subjects based on predetermined criteria. Subsequently, semi-structured individual interviews were conducted to explore their creative thinking processes in more depth. In the final stage, all data obtained from the questionnaires, written test results, and interview transcripts were collected and prepared for analysis.

Data Analysis

The data analysis in this study is based on the interactive model of Miles and Huberman (2013) which involves three stages including data condensation, data display and conclusion drawing. In the data condensation phase, all the interview results are recorded, transcribed in full, and selected for information relevant to the four indicators of creative thinking, classified by subject codes. In the stage of data presentation, the research findings are presented in the form of narrative descriptions supported by interview quotes and students' written responses. In the stage of drawing conclusions, the patterns of creative thinking are identified by comparing data from S-1 and S-2 for each indicator. Method triangulation was used to establish the credibility of the findings by comparing students' written responses with the corresponding interview transcripts to ensure consistency of interpretation. After analyzing the case individually, the next step was to do a cross-case comparison to find similarities and differences in the creative thinking profile of S-1 and S-2 in the four indicators of creative thinking. The coding process and analytical decisions were audited throughout the analysis in an effort to improve the trustworthiness of the findings.

RESULT

The results of Florence Littauer's personality type questionnaire on 26 students of grade VII showed that there were 6 students with sanguine personality type, 7 students with choleric personality type, 9 students with melancholic personality type, and 4 students with phlegmatic personality type. Two of the six sanguine students were selected as research participants, based on teacher recommendations and predetermined eligibility criteria. Two of the six sanguine students were given the codes S-1 and S-2. Both participants were classified as having moderate mathematical ability. After completing the creative thinking test, each participant took part in an individual semi-structured interview. The credibility of the findings was strengthened through method triangulation by comparing each participant's written responses with the corresponding interview data. Subsequently, a cross-case comparison was conducted to identify similarities and differences in the creative thinking profiles of S-1 and S-2 across the four indicators proposed by Munandar Munandar (1987).

Fluency

Sanguine Subject 1 (S-1)

Based on the answer sheet, S-1 can understand the question and produce 4 valid pairs of selling prices. These four pairs meet both given requirements, namely a minimum profit of Rp 90.000 and provisions $q < p$.

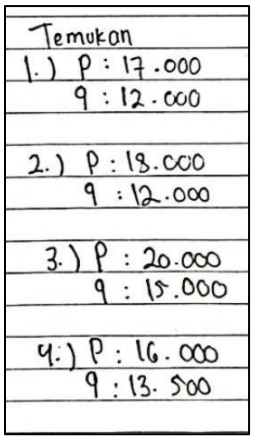

Figure 1. S-1 answer on the Fluency Indicator

During the interview, S-1 confirmed each of the price pairs obtained and explained that the first pair was found through trial and error rather than by a direct approach. The interview excerpt with S-1 is as follows:

Researcher : "After finding your first partner who meets the criteria, do you stop or continue searching?"
S-1 : "I continued because the question asked to find as many as possible."
Researcher : "Do you think there are other partners you have not found yet?"
S-1 : "Maybe, because if you think about it, the number could be very large."

Based on the analysis of the answer sheet and interview, S-1 meets the fluency indicator because they can produce 4 valid price pairs, continue searching for alternative answers, and understand that the given problem has more than one possible solution.

Sanguine Subject 2 (S-2)

The S-2 subject understands the problem and knows the steps needed to solve it: find as many pairs of selling prices (p and q) as possible that meet the minimum profit requirement of Rp 90.000, with the condition q < p.

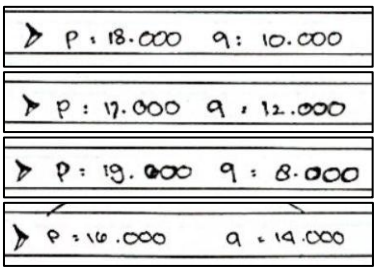

Figure 2. S-2 answer on the Fluency Indicator

During the interview, S-2 correctly recalled all four valid price pairs and explained that these pairs were obtained by first determining q, then finding the corresponding p, rather than by random guessing. An excerpt from the interview with S-2 is presented as follows:

Researcher : "After finding the first suitable partner, do you stop or continue searching?"
S-2 : "I did not stop because the question was to find as many as possible,so I kept looking until I got 4."
Researcher : "Do you feel that there is one more partner you could have missed?"
S-2 : "There might be more, but I am tired of counting, so four is enough"

Following the evaluation of the response sheet and discussions, S-2 meets the fluency indicator because they can produce four valid price pairs, correct incorrect answers, actively seek alternative solutions, and are aware that there may still be other solutions.

Flexibility

Sanguine Subject 1 (S-1)

According to the answer sheet, S-1 employs two distinct resolution strategies. In the first strategy, S-1 employs a direct substitution approach by estimating a selling price that is considered reasonable based on market prices, and then checks whether total sales meet the specified requirements.

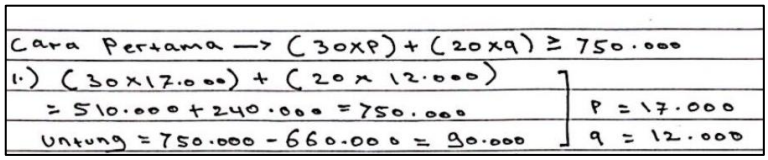

Figure 3. S-1 answer on the Flexibility Indicator (first method)

In the second strategy, S-1 first determines the value of p, then finds the minimum value of q through algebraic manipulation of inequalities.

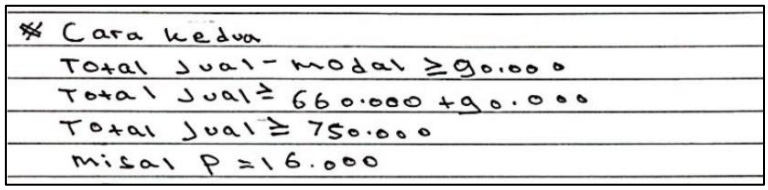

Figure 4. S-1 answer on the Flexibility Indicator (second method)

During the interview, S-1 explained:

Researcher : "What strategy do you use? Can you explain the difference?"

S-1 : "In the first method, I estimate the selling price based on the common rice prices in the market, then try several possible values that are appropriate. In the second method, I set the value of p first, then determine the minimum q through calculations."

Researcher : "If the first strategy suddenly cannot be used, what other way can you use?"

S-1 : "I will use the second method. Alternatively, maybe start with the smallest number and keep increasing. However, basically, it is still just experimenting."

Based on the written work and interview data, S-1 demonstrated procedural flexibility by employing two different solution procedures and suggesting an alternative procedure during the interview. However, both procedures relied on the same numerical–algebraic representation, providing limited evidence of broader representational or conceptual flexibility.

Sanguine Subject 2 (S-2)

On the answer sheet, S-2 also uses two different solving strategies. In the first strategy, S-2 first determines the value of q by considering that yellowing rice has a lower selling price, then determines the value of p based on the given total sales requirement.

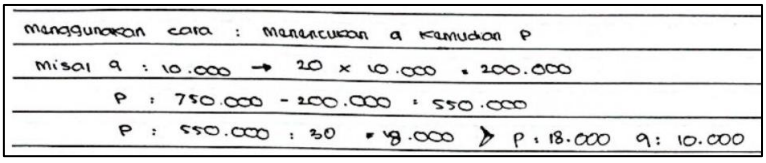

Figure 5. S-2 answer on the Flexibility Indicator (first method)

In the second strategy, S-2 uses a rice cost price of Rp 13.200 per kilogram as the initial reference, then develops solutions based on that value.

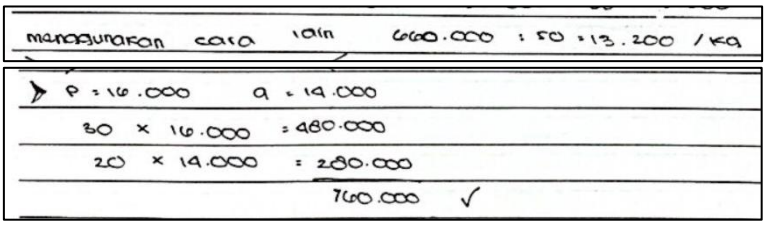

Figure 6. S-2 answer on the Flexibility Indicator (second method)

During the interview, S-2 explained:

Researcher : "Can you explain the difference between your two methods?"
S-2 : "The first way, I determine q first because I think about how much the usual yellowing rice costs, then I find p. The second way, I remember the cost price of 660,000 divided by 50 kg is 13,200 per kg, and I start from there."
Researcher : "Are these two strategies really different from each other?"
S-2 : "Different, but not too far."
Researcher : "What will you do if the first strategy fails?"
S-2 : "I will resort to the second strategy, but since it is quite complex, if there is another alternative other than the second strategy, I will go for it."

S-2 exhibited procedural flexibility using two solution procedures with different starting points based on written work and interview data. Both procedures, however, occurred within the same mathematical representation and did not reflect more general representational or conceptual flexibility. S-2 agrees that the process of both strategies is similar, but the first strategy starts with the selling price and the second strategy starts with the cost price as the starting point for problem solving.

Originality

Sanguine Subject 1 (S-1)

Once all students' responses have been collected and analyzed, authenticity is assessed comparatively. The results of the comparison show that the first strategy adopted by S-1, based on trial and error exploiting intuition about market prices, and the second strategy based on manipulation of algebraic inequalities, were also adopted by most of the other subjects of this study. S-1 also was not able to confirm in the interview whether the strategy he used was different than strategies used by other students. The following is an excerpt from the interview with S-1:

Researcher : "How did you find this solution? Did you find it yourself?"
S-1 : "The first method is the one I always use when I do not know where to start. The second method, I think I was taught in class before, but I forgot the material."
Researcher : "Did any of your friends tell you how to do this before you started?"
S-1 : "No, because the questions were done individually at that time."
Researcher : "Do you think there is a part of your solution that is different from your classmate's solution?"
S-1 : "I do not know, I did not see my friends."

Based on the comparative analysis of all subjects, S-1's strategy contains no unique elements. The two approaches used are also found in other subjects, and S-1 admits that the

first strategy is common, while the second is derived from a previously learned method. Therefore, S-1 has not yet met the originality indicator.

Sanguine Subject 2 (S-2)

Based on the results of the comparative analysis, the strategy used by S-2, which involves determining the value of q first, then finding the value of p in the first strategy, as well as using the cost price per kilogram as a reference in the second strategy, is essentially still aligned with the direct substitution approach also used by most other subjects. Although there are differences in the order of variable determination, these differences do not indicate fundamentally different approaches mathematically. During the interview, S-2 explained as follows:

Researcher : "How did you come up with the idea for this solution?"
S-2 : "The first method I invented myself while reading the question. I think the yellow rice is more of an issue, so I started with that one. For the second method, I learned from a lesson that if you buy goods and then resell them, there is a cost price, so I used that."
Researcher : "Did anyone tell you the solution before you started?"
S-2 : "No, you yourself asked us to work individually and not to copy."

Based on the comparative analysis of all subjects, S-2's strategy shows no distinctive characteristics compared to those of the other subjects. Therefore, S-2 has not yet met the originality indicator.

Elaboration

Sanguine Subject 1 (S-1)

On the answer sheet, S-1 has not written detailed verification, reasons, or justifications for each step of the solution. In the first strategy, S-1 listed only the substitution process and the total sales result, without explaining the basis for selecting the price values used. Meanwhile, in the second strategy, the calculation steps are written briefly without accompanying explanations at each stage of the solution.

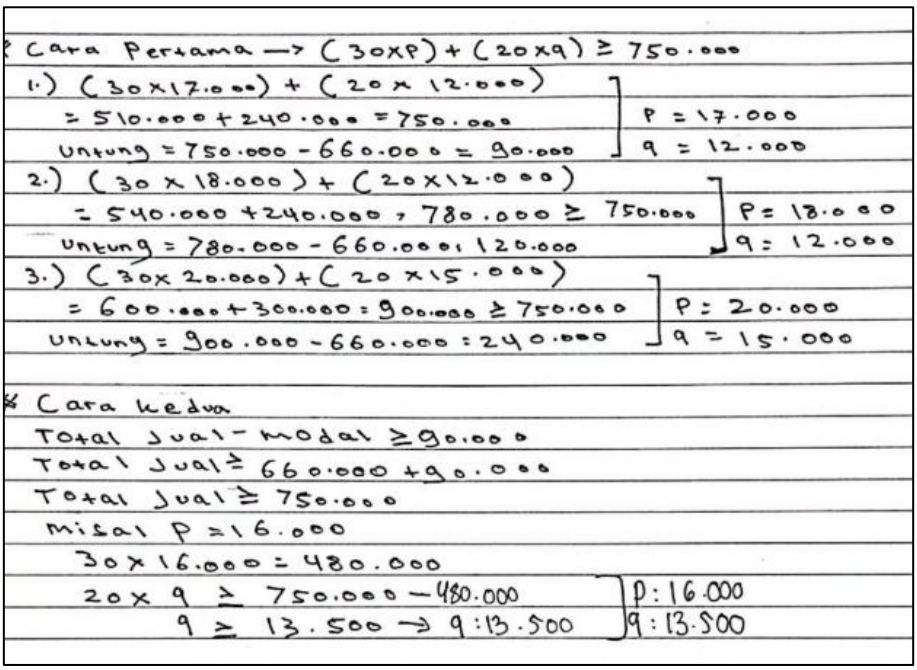

Figure 7. S-1 answer on the Elaboration Indicator

During the S-1 interview, it was explained:

Researcher : "Can you explain in detail the steps you used to solve this problem?"
S-1 : "The first way, I try some numbers that I think can meet the minimum of Rp 750,000. For example, p = 17,000 and q = 12,000, then I calculate the total. If the total is Rp 750,000 or more, then it is successful. Then I try other numbers. The second way, I choose p first to find q as I wrote."
Researcher : "In the second strategy, why did you choose that p-value?"
S-1 : "Because at the rice shop, that price is reasonable."
Researcher : "After finding each pair, do you always check if it meets all the requirements?"
S-1 : "I only checked a few at the beginning. But for the rest, I just looked at the pattern."
Researcher : "Did you verify that q is < p as well?"
S-1 : "Yes but I just looked and did not write it down. If q looks smaller than p, it is correct."

The response sheet evaluation and discussions, S-1 has not reached the elaboration indicators. This is evidenced by the lack of explicit verification of the q condition, the use of 'less than', the insufficient mathematical justification in the selection of values, and the incomplete and non-systematic process of checking the next price pair.

Sanguine Subject 2 (S-2)

On the answer sheet, S-2 did not show the step-by-step computations for the second and third pair of numbers in the first strategy but rather just wrote the final answers. The same thing happened in the second strategy where some of the steps were not completely shown resulting to an unclear transition of operations. Additionally, S-2 did not include a written verification of the solutions obtained.

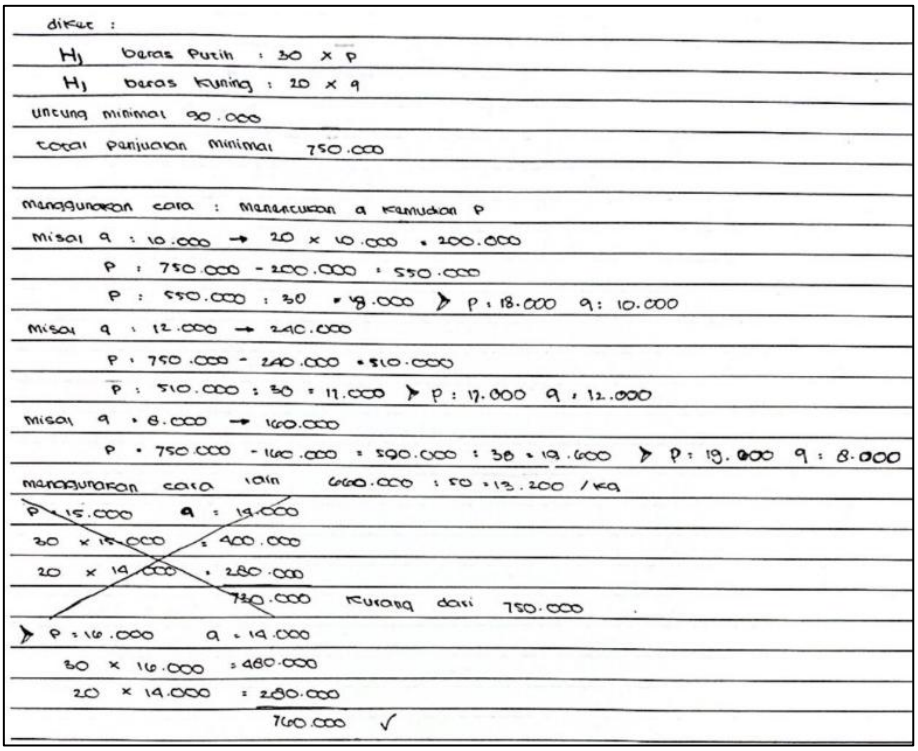

Figure 8. S-2 answer on the Elaboration Indicator

During the S-2 interview, it was explained:

Researcher : "Can you explain in detail the steps you used?"

S-2 : "In the first method, I choose q = 10,000, then multiply by 20, resulting in 200,000. Then, subtract Rp750,000 minus Rp200,000 = Rp550,000, divided by 30 equals Rp18,333. I round it to 18,000, so p = 18,000. Then I try another value using the same method. In the second method, I remember the cost price is 13,200 per kg, then I calculate as I wrote."
Researcher : "In the first strategy, why did you choose q = 10,000?"
S-2 : "I do not know. I chose 10,000 because it is easier to count."
Researcher : "After finding each pair, do you check whether all the conditions are met?"
S-2 : "What are the requirements? The one that must be more than 750,000?"
Researcher : "Yes, but there is also a requirement that q must be less than p."
S-2 : "I have checked it, but I did not record it."
Researcher : "Have you ever found a partner who seemed genuine, but turned out not to be qualified?"
S-2 : "The one I crossed out earlier. After adding everything up, it only amounted to Rp 730,000."

According to the analysis of answer papers and interviews, S-2 does not reach the level of elaboration of the indicator. It can be seen from the fact that there are no calculation details regarding certain price pairs, there is no written evidence for the condition $q < p$, as well as the fact that S-2 cannot remember one of the conditions of the problem without the help of the researcher at the beginning of the interview. The values chosen are also not sufficiently mathematically justified.

The overall achievement of creative thinking indicators for both subjects with sanguine personality types is presented in Table 2.

Table 2. Achievement of Creative Thinking Indicators in Sanguine Subjects

Creative Thinking Indicator	S-1	S-2	Cross-case Comparison
Fluency	Fulfilled	Fulfilled	Consistent pattern
Flexibility	Fulfilled	Fulfilled	Consistent pattern
Originality	Not fulfilled	Not fulfilled	Consistent pattern
Elaboration	Not fulfilled	Not fulfilled	Consistent pattern

DISCUSSION

This study aims to analyze the creative thinking ability of middle school students with sanguine personality types in solving open-ended problems in social arithmetic based on four indicators proposed by Munandar (1987). In this discussion personality is not used as an explanatory cause. Rather the mathematical behavior that is seen in the two cases is described, the sanguine framework is explored as one possible interpretation and alternative explanations that do not rely on personality categorization are explored.

Both subjects generated four valid pairs of selling prices. They continued to look for answers beyond the initial answer found, satisfying the fluency indicator by producing a lot of correct and relevant answers (Munandar, 1987). Both participants used two different solution procedures: S-1 used a trial-and-error approach based on estimated market prices and an algebraic inequality approach, and S-2 used procedures differing in starting point (selling price vs. cost price). This implies variability in procedures for problem solving rather than more general representational or conceptual flexibility, as all strategies were still within the same numerical algebraic framework. Neither subject explicitly verified the conditions of q less than p, nor did they provide a complete step-by-step explanation or adequate mathematical reasoning. The strategies used by both subjects were also commonly observed among students

with other personality types, indicating that the solutions were not distinctive or original as defined by Munandar (1987) and Guilford (1967).

These patterns are consistent with the sanguine profile described by Littauer (1992): spontaneity and readiness to generate ideas support fluency, and adaptability supports procedural variation, but a tendency to move quickly without deeper reflection may limit originality, while a tendency to be less detailoriented may limit elaboration. This corresponds to Bruhn & Lüken (2023) in terms of fluency in open-ended mathematical tasks, to Torrance's (1974) understanding of flexibility as a change in ways of thinking (which is only observed here at the procedural level), and to Meier et al. (2024) and Sipahi & Bahar (2025) in terms of the importance of complete reasoning in creative mathematical thinking. Since elaboration in sanguine students has not been extensively studied by Meier et al. (2024), this study extends prior findings by showing that detail remains an area for development.

In these two cases, the participants' spontaneous response patterns coincided with rapid idea generation, while their solutions showed limited checking and written detail. These patterns may be interpreted through the sanguine framework, but they may also reflect mathematical experience, task design, and classroom norms. Students may already possess appropriate solution ideas but be unfamiliar with classroom expectations for explaining and justifying reasoning in detail, or may not have been explicitly taught to verify constraints in open-ended tasks. This suggests that limited elaboration may not solely reflect a personality-linked cognitive tendency, and points toward an instructional rather than purely dispositional account of the findings.

The strongest claim supported by these two cases is not that sanguine students are simply fluent and flexible but not original or elaborative. Rather, the cases illustrate that producing several answers and varying procedural starting points does not necessarily lead to mathematically original, generalized, or fully verified solutions. Open-ended instruction should therefore combine opportunities for idea generation with explicit prompts for representation, justification, and constraint checking, for example, structured solution templates that prompt students to (1) state the mathematical strategy used, (2) justify the selection of values or procedures, (3) verify that each solution satisfies all problem constraints, and (4) explain why the solution is mathematically valid.

Several methodological limitations should be considered when interpreting these findings. First, the Florence Littauer personality questionnaire classifies students according to a dominant personality tendency, whereas personality is multidimensional and may vary across situations; the participants' classifications should therefore be viewed as descriptive rather than fixed psychological categories. Second, participants were selected because they demonstrated at least two creative-thinking indicators and were able to communicate their reasoning during interviews. Hence, the findings represent information-rich cases rather than the full range of creative thinking among sanguine students. Third, the analysis was based on a single open-ended task on the topic of social arithmetic within a single school; students' creative thinking profiles may differ across other mathematical topics, task types, or school contexts. Future studies could involve multiple tasks across mathematical domains and multiple schools, employ additional personality measures, and include participants with more diverse levels of creative thinking to improve the robustness and transferability of the findings.

CONCLUSION AND SUGGESTIONS

In both cases both participants produced more than one candidate solution and switched between more than one solving approach. These responses were coded as fluency and flexibility according to the coding criteria of the study. No statistically infrequent strategy was exhibited by either participant. Both participants had incomplete written justification and verification. These results pertain to the selected participants and task and should be regarded as exploratory

case patterns and not a general profile of students categorized as sanguine. The two participants generated several candidate solutions and their procedures differed somewhat. However, their solutions mainly relied on well-known trial, substitution or inequality-based methods and not necessarily verified all the problem constraints. So the results show a difference between generating many ideas and developing mathematically original, general and well-justified solutions. While the response patterns observed can be understood in terms of the participants' dominant sanguine classification, they should not be regarded as invariable features of all students with the same personality label. The instruction should be able to support quick idea generation but systematic checking, alternative representations and explicit mathematical justification are necessary.

The findings from the research indicate that teachers need to provide explicit instructional scaffolds to students to comprehend the expected format of mathematical explanations. Teachers can provide structured solution frameworks that help students to (1) recognize the strategy, (2) justify each step in the calculation, (3) check that all constraints are met and (4) articulate why each solution is mathematically valid. Such guidance may promote students' development of more systematic mathematical reasoning and enhance the elaboration dimension of creative thinking. Students should also learn to write full solution steps and to experiment with different approaches to problem solving. Moreover, future studies should incorporate more heterogeneous samples and materials, and should explore the efficacy of learning interventions in improving authenticity and detail without negatively impacting students' fluency and flexibility.

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