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Investigating Students' Mathematical Problem-Solving Abilities in the Context of Social Arithmetic through the Lens of Learning Styles

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ABSTRACT

This study investigates how students solve mathematical problems in social arithmetic and examines the influence of different learning styles on their problem-solving performance. Although mathematical problem solving has been widely studied, limited attention has been given to how students' learning styles interact with specific domains such as social arithmetic, which requires both conceptual understanding and procedural fluency. The study involved 20 seventh-grade students from SMPN 013 Satu Atap Bukit Bestari, Indonesia, and employed a qualitative descriptive design. Three instruments were used: a learning style questionnaire to categorize students into visual, auditory, and kinesthetic groups; a written test structured according to Polya's four stages of problem solving; and semi-structured interviews to explore students' reasoning processes in each stage. The findings showed that kinesthetic learners achieved the highest results across all indicators of problem solving. Auditory learners were proficient in understanding problems and planning strategies but struggled with evaluating their answers, while visual learners displayed strong initial comprehension but faced challenges in developing and implementing solution plans. Classroom elements such as group discussions and oral presentations were found to enhance engagement, particularly for kinesthetic learners. Overall, the study highlights the importance of aligning instructional approaches with students' learning styles to improve mathematics learning outcomes. These results provide empirical support for differentiated instruction in mathematics, especially for context-based topics like social arithmetic that remain underexplored in current learning styles research.

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Introduction

Education is a conscious effort to develop individual potential through learning processes, the surrounding environment, and life experiences. The learning process aims to foster knowledge, skills, competencies, and changes in attitudes and behavior within individuals. According to Law No. 20 of 2003 Article 1, education is defined as a planned and conscious effort to create a learning environment and process that enable students to actively develop their potential to possess spiritual strength, self-control, personality, intelligence, noble character, and the skills required for themselves, society, the nation, and the state. Mastery of knowledge and skills is therefore expected to equip individuals to face various challenges in their daily lives.

In this context, mathematics serves as one of the essential disciplines that helps individuals find solutions to real-life problems. Mathematics learning provides a fundamental basis for education and plays a vital role in solving diverse problems encountered in daily situations (Usman, Patalo, & Djadir, 2021). Mathematics education at all levels (from elementary to higher education) is crucial for developing logical, analytical, and systematic thinking, as well as fostering critical, creative, and collaborative skills (Utari, 2023). The competencies developed through mathematics align with the demands of 21st-century learning, which emphasizes higher-order thinking skills, the integration of technology, and the ability to solve complex problems (Mu'minah, 2021). In line with this, Siswanto & Meiliasari (2024) emphasize that students must possess problem-solving skills to construct understanding, apply concepts, and generate solutions.

Solving mathematical problems requires individuals to think logically, critically, systematically, and persistently until a solution is found (Azhar, Saputra, & Nuriadin, 2021). A learning process that encourages students to actively participate, respond thoughtfully, and overcome challenges in solving problems is an indicator of strong problem-solving ability. However, various reports indicate that students' mathematical problem-solving skills in Indonesia remain low. According to the 2022 Programme for International Student Assessment (PISA) results released by the OECD in 2023, Indonesia ranked 69th out of 81 countries, with an average score of 366, far below the global mean of 489. These results suggest that Indonesian students' mathematical proficiency is still below the international standard, as reflected in their limited competencies in critical thinking, creativity, problem solving, and reflection (Lestari et al., 2024). Weak problem-solving skills often cause students to perceive difficulties as barriers rather than challenges, ultimately leading to low academic achievement (Rahmatiya & Miatun, 2020).

One contributing factor to these weak problem-solving skills is the lack of instructional approaches that address individual learning needs and differences. Each student has unique strengths and limitations in processing and understanding information (Anjela Safira et al., 2024). In line with Ki Hajar Dewantara's philosophy, every individual possesses unique characteristics and learning tendencies (Afdillah, 2024; Darmawan, 2024; Efendi, 2023; Sholihah, 2021). Therefore, a differentiated learning approach that considers students' learning styles is essential, as learning styles influence how students absorb and process information (Anjela Safira et al., 2024).

Previous studies have shown that learning styles significantly affect students' mathematical problem-solving abilities. For instance, Setiyanik (2020) found that students with visual and auditory learning styles demonstrated stronger mathematical problem-solving skills than those with kinesthetic styles. These findings indicate that learning styles play an important role in shaping students' problem-solving performance. Since each student learns differently (whether visually, auditorily, or kinesthetically) understanding learning styles can help teachers apply more effective instructional strategies to enhance mathematical problem-solving skills.

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Although numerous studies have explored the relationship between learning styles and mathematical problem solving, limited research has focused on this relationship within the context of social arithmetic at the junior high school level. Therefore, this study aims to analyze students' mathematical problem-solving abilities in social arithmetic based on their learning styles. The central research question guiding this study is: "How do students' mathematical problem-solving abilities in social arithmetic differ according to their learning styles?"

Method

Type of Research

This study employed a qualitative research design with a descriptive approach. This design was chosen based on the research question, which aimed to analyze and describe in depth students' mathematical problem-solving abilities in social arithmetic in relation to their visual, auditory, and kinesthetic learning styles. The descriptive qualitative approach was considered appropriate because it enabled the researcher to explore phenomena naturally, describe students' thinking processes in solving problems, and analyze differences in solution strategies that emerged according to each learning style. Thus, this design provided a comprehensive Figure of how learning styles influence the way students solve problems in social arithmetic.

Research Subjects

The research population consisted of all students in Class VII-B at SMPN 013 Satu Atap Bukit Bestari during the 2025/2026 academic year. The research subjects were selected using purposive sampling based on specific criteria, namely three students who obtained the highest scores for each learning style category (visual, auditory, and kinesthetic).

Instruments

The research instruments comprised three components: (1) an online learning style questionnaire, (2) a mathematical problem-solving test, and (3) semi-structured interview guidelines. The learning style questionnaire was administered via the "Aku Pintar" platform, which has been validated for practical use, as reported by Sihombing (2024). The mathematical problem-solving test was developed based on Polya's four problem-solving indicators, whereas the interview guidelines were designed to explore students' thinking processes, solution strategies, and the relationship between learning styles and problem-solving approaches in greater depth. Prior to use, all instruments were validated to ensure their feasibility and content validity. The mathematical problem-solving test was validated by mathematics teachers, while the semi-structured interview guide was validated by university lecturers. Validation focused on the suitability of indicators, clarity of language, and relevance of the instrument to the research objectives.Data on student learning styles were collected through an online questionnaire using the Aku Pintar platform (https://akupintar.id/mp/tes-gaya-belajar), which classifies students as visual, auditory, or kinesthetic learners. The following figure presents an example of a questionnaire statement:

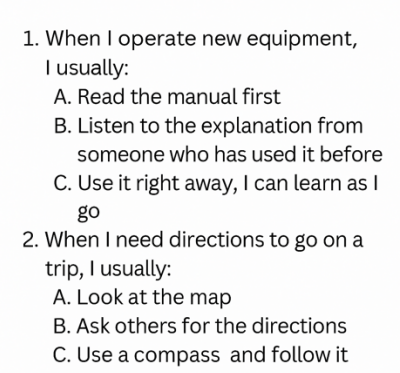
1. When I operate new equipment, I usually:
   A. Read the manual first
   B. Listen to the explanation from someone who has used it before
   C. Use it right away, I can learn as I go
2. When I need directions to go on a trip, I usually:
   A. Look at the map
   B. Ask others for the directions
   C. Use a compass and follow it

Figure 1. Example of a Learning Style Questionnaire Statement

To measure students' mathematical problem-solving abilities according to their learning styles, a written test was administered. The test consisted of two essay questions designed in accordance with Polya's indicators. The first item assessed cognitive level C4, and the second assessed level C5, both using social arithmetic contexts.

Table 1. Description of Test Items

Task	Question Characteristics
Question 1. Mrs. Tuti bought 1,000 chicken eggs from a farmer at Rp1,500 each. She requested delivery to her shop at a cost of Rp15,000. The eggs were sold for Rp2,000 each. After a week, 150 eggs remained unsold, prompting her to reduce the price to Rp1,900. Twenty eggs spoiled and were discarded. Determine the percentage of profit or loss obtained by Mrs. Tuti.	Calculate the total cost and total revenue, then determine the actual profit or loss percentage based on the given situation.
Question 2. Mr. Tono plans to open a grocery store beside his house. He purchased five sacks of granulated sugar for Rp600,000 each. Each sack has a gross weight of 20 kg and a tare of 1%. Before deciding how to sell the sugar, Mr. Tono considers two options: (1) sell retail at Rp15,000/kg and sell each sack for Rp1,000, or (2) sell all to a wholesaler for Rp1,475,000. Which method yields greater profit?	Compute the net sugar weight after deducting the tare, determine total revenue for both methods, and identify which option results in maximum profit.

Semi-structured interviews were conducted to explore students' thought processes, problem-solving strategies, and the relationship between learning styles and problem-solving methods. These interviews were conducted with the same subjects as the written test, as part of data triangulation. Table 2 shows the interview guidelines used in the study.

Table 2. Interview Guidelines

Problem-Solving Stage	Indicators
Understanding the Problem	Students are able to: (1) restate the problem clearly in their own words; (2) identify key information; (3) point out unclear parts of the question (if any); and (4) explain strategies to ensure comprehension, such as rereading or summarizing information.
Planning the Solution	Students are able to: (1) present logical and relevant initial steps; (2) explain the chosen methods or strategies and justify their selection; (3) consider alternative strategies; and (4) outline a systematic work plan.
Implementing the Plan	Students are able to: (1) explain the execution process; (2) identify obstacles encountered and how they were overcome; and (3) reflect on the consistency between plan and implementation.
Checking the Results	Students are able to: (1) describe steps taken to verify their answers; (2) explain how they confirmed accuracy, identified mistakes, and made corrections; and (3) demonstrate understanding of the importance of final evaluation in problem solving.

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Procedures

The data collection techniques in this study consisted of three main stages, namely administering a learning style questionnaire, a mathematical problem-solving test, and semi-structured interviews. First, data on students' learning styles were collected through an online questionnaire using the *Aku Pintar* platform (https://akupintar.id/mp/tes-gaya-belajar), which grouped students into visual, auditory, or kinesthetic learning styles. Second, the mathematical problem-solving test consisted of two essay questions designed based on Polya's problem-solving ability indicators. The first question measured the C4 cognitive level and the second question measured the C5 level, with material on social arithmetic. Third, interviews were conducted to explore students' thinking processes, solution strategies, and the relationship between learning styles and problem-solving methods. These interviews were conducted with the same subjects as the written tests as part of data triangulation.

Analysis

Data analysis was conducted descriptively, where test results were analyzed to measure problem-solving abilities, while interview results were analyzed thematically to identify problem-solving patterns that emerged in each learning style category. To ensure data validity, this study applied triangulation techniques through three approaches. First, source triangulation was conducted by comparing data from three subjects representing each learning style. Second, method triangulation was applied by confirming findings through different data collection techniques (written tests, in-depth interviews, and observations). Third, data triangulation was conducted by verifying the consistency between the results of the problem-solving ability test and the in-depth interview data for each subject. These steps were taken to ensure the credibility of the findings and reduce subjectivity in data interpretation.

Results

From the results of the questionnaire completed by students in class VII-B, data was obtained regarding the learning style category of each student. The number of students in each learning style category can be seen in Table 3.

Table 3. Learning Style Questionnaire Results Data

Learning Style	Number of Students
Visual (V)	6
Auditory (A)	3
Kinesthetic (K)	11

Next, based on the results of the problem-solving ability test, the researchers selected three students to study. They chose the students with the highest test scores for each learning style: AM for visual learning style, SF for auditory learning style, and MR for kinesthetic learning style. The following are the subjects' answers to Polya's problem-solving ability indicators.

Subjects with visual learning styles

The subject representing the visual learning style category is AM. AM completed both questions given. Question number 1 was about buying and selling activities, in which Mrs. Tuti bought 1,000 eggs and sold them at two different prices because there were leftovers that had to be discounted and some were damaged. This question asked for the calculation of the percentage profit from the entire transaction. Question number 2 also contained a buying and selling activity in which Mr. Tono bought 5 sacks of sugar and considered two sales methods, namely retail or wholesale. This question asked for an analysis of the profits from both options in order to determine the best sales strategy. The results of subject AM's answers are shown in Figures 2(a) and 2(b) below.

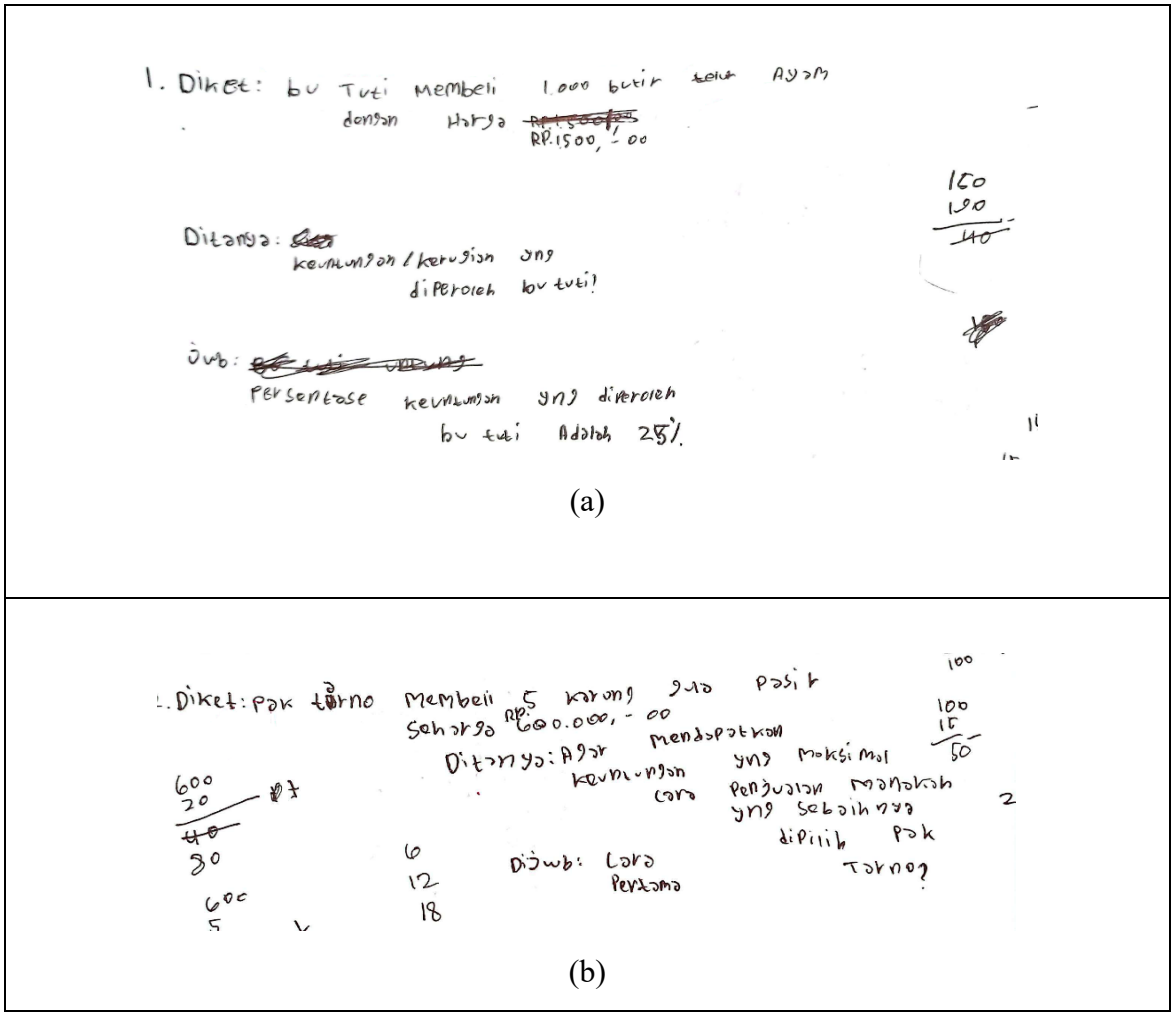

Figure 2. (a) Answer to question number 1, (b) Answer to question number 2 subject AM

In question number 1, AM wrote down information about the number of eggs purchased by Mrs. Tuti and the purchase price per egg. Meanwhile, in question number 2, AM only wrote down the purchase price of five sacks of granulated sugar. In addition, AM also wrote down what was asked in both questions.

From the answers, it appears that AM has not written down all the known information completely. In question number 1, AM should also have written down other information such as delivery costs, the selling price of eggs, and the number and price of eggs sold at a lower price. In question number 2, AM has also not written down all the available information, such as the gross weight per sack, the retail price of granulated sugar, the selling price of used sacks,

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and price offers from other traders. Thus, it can be concluded that the subject AM does not fully understand the problem given.

The difficulty in understanding this problem also affects the next step. From the answers to questions 1 and 2, AM has not planned the solution steps in advance. In fact, there should be a solution planning process, such as calculating the net weight, total income from the sale of sugar and sacks, calculating the profit, and comparing the options to determine which one is more profitable.

Due to the lack of clear planning, AM also failed to carry out the steps to solve the problem in a structured manner. AM simply tried to solve the problem by trial and error, using multiplication and addition operations randomly without any systematic order.

To obtain more in-depth information about the rechecking process, the researcher interviewed subject AM. The interview results confirmed that AM did not recheck his answers. This was stated directly by AM in the following conversation:

P : *"After understanding the question, what does AM usually do next?"*
AM : *"I just understand the question, then I write down what is known, what is asked, and the answer. I just try to do it."*

This statement further clarifies that AM students did not evaluate their answers, resulting in inaccurate answers.

Subjects with auditory learning styles

The subject representing the auditory learning style category is SF. Of the two questions given, SF only answered question number 1. Question number 1 was about buying and selling activities in which Mrs. Tuti bought 1,000 eggs and sold them at two different prices because there were leftovers that had to be discounted and some were damaged. This question asked for the calculation of the percentage profit from the entire transaction. The results of subject SF's answers are shown in Figure 3 below.

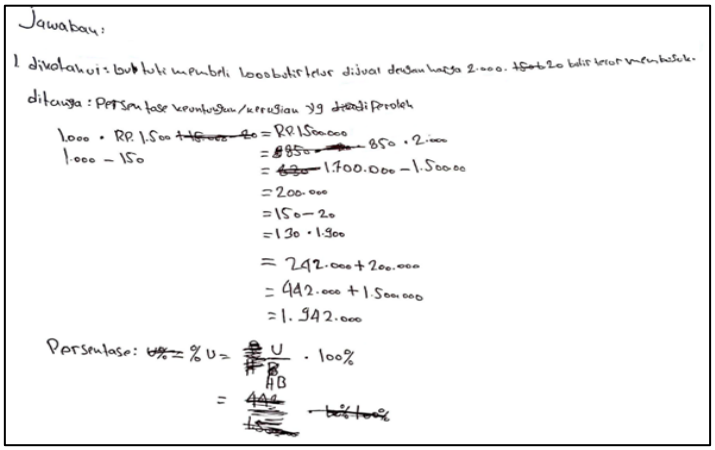


Figure 3. Answer to question number 1, subject SF

Based on the image above, SF only wrote down information such as the number of eggs, the selling price per egg, and the number of rotten eggs. SF also wrote down what was asked in the question. SF should have also included other information such as the purchase price of the eggs, delivery costs, and the number of eggs sold at a discount. Thus, it can be concluded that SF did not fully understand the problem.

Furthermore, in the planning stage, SF showed an effort to develop calculation steps, even though they were not explicitly written as a plan. SF planned to solve the problem by developing a strategy through the creation of a profit percentage formula, even though it appeared to be directly translated into calculations without an initial statement of the plan. Based on this indicator, SF is quite good at planning, but not yet optimal because it is not structured as it is written at the end and has not been completed.

When implementing the plan, SF made calculations that were not in line with the initial plan. As a result, SF only made trial and error calculations without a clear strategy. This shows that SF was not yet able to consistently implement the plan that had been made, so that the completion process became less focused and risked producing incorrect answers.

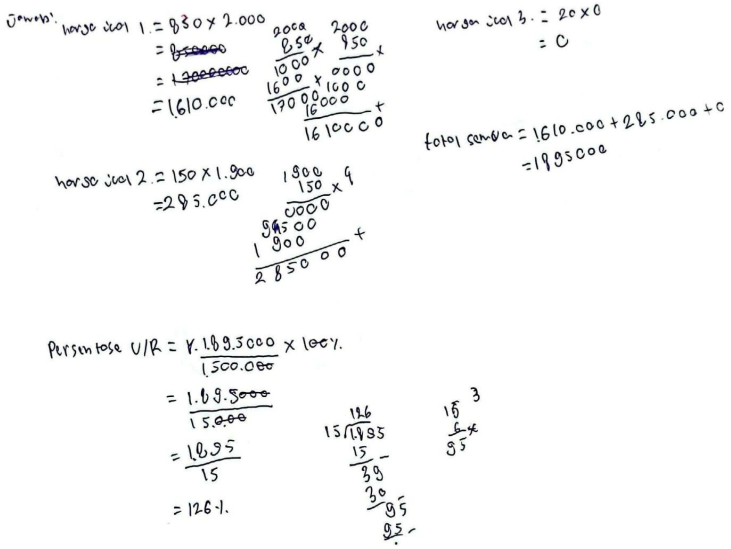
To obtain in-depth information about the rechecking process, the researcher interviewed SF. The results of the interview proved that SF did not recheck his answers. This was conveyed directly by SF in the following conversation:

P : *"Did SF not recheck his answers after working on the questions?"*
SF : *"No"*

This statement further clarifies that SF did not evaluate his answers, indicating that SF does not yet have the habit of rechecking his work process and results.

Subjects with a kinesthetic learning style

The subject representing the kinesthetic learning style category is MR. MR completed both questions given. Question number 1 was about buying and selling activities, in which Mrs. Tuti bought 1,000 eggs and sold them at two different prices because there were leftovers that had to be discounted and some were damaged. This question asked for the calculation of the percentage profit from the entire transaction. Question number 2 also contained a buying and selling activity in which Mr. Tono bought 5 sacks of sugar and considered two sales methods, namely retail or wholesale. This question asked for an analysis of the profits from both options to determine the best sales strategy. The results of subject MR's answers are shown in Figures 4(a) and 4(b) below.



(a)

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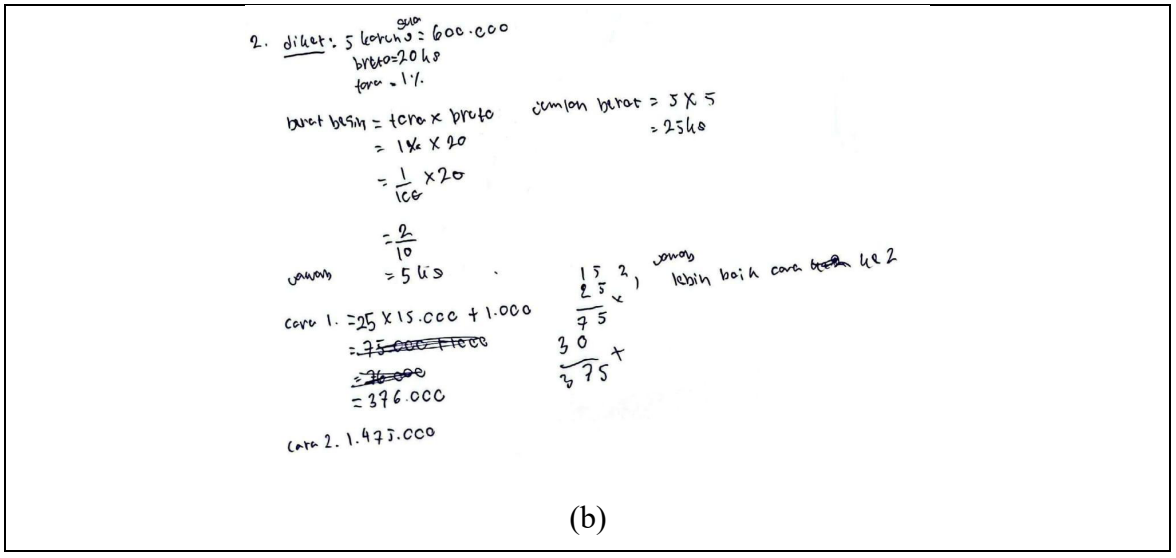

Figure 4. (a) Answer to question number 1, (b) Answer to question number 2 subject MR

Based on the answers above, student MR has not provided complete information in question number 1. MR only wrote down the number of eggs and the delivery cost. Student MR should have written down other information such as the purchase price of the eggs, the number of rotten eggs, and the number of eggs sold at a discount. As for question number 2, MR also did not write down all the information in the question, such as the retail price of granulated sugar, the selling price of used sacks, and price offers from other traders. Furthermore, in the planning stage, MR calculated the selling price and the percentage of profit or loss for question number 1. In question number 2, MR wrote down the formula for net weight.

In the next stage, MR carried out the plan in question number 1 by calculating the selling price and the percentage of profit or loss. However, MR's calculations still contained errors, resulting in an inaccurate answer. Nevertheless, in question number 2, MR still carried out the solution plan by calculating the net weight, calculating the cost of sales, and considering the most profitable option.

To obtain more in-depth information about the review process, the researcher interviewed the subject, MR. The interview results showed that MR reviewed his answers. This was conveyed directly by MR in the following conversation:

P : *"After getting the answer, what do you do next?"*
MR : *"Make sure the order is correct."*
P : *"Is that like checking?"*
MR : *"Yes"*
P : *"How does MR check to see if the answer is correct?"*
MR : *"Recalculate."*

This statement further confirms that MR evaluates his answers by rechecking his calculations.

Discussion

The purpose of this study was to evaluate students' ability to solve mathematical problems based on their learning styles in social arithmetic. The research referred to four indicators of mathematical problem solving developed by Polya: (1) understanding the problem, (2) planning the solution, (3) implementing the plan, and (4) checking the solution. Students' learning styles

were examined as a factor influencing variations in the problem-solving process. The results showed that students' abilities to meet the problem-solving indicators varied, with learning styles affecting how they understand, process, and apply information when solving mathematical problems.

Problem-Solving Skills of Students with a Visual Learning Style

The results indicated that AM, who has a visual learning style, did not fully understand the given questions. This was evident from AM's responses, which lacked important information needed to facilitate the problem-solving process. In addition, AM did not perform structured planning and tended to rely on trial and error without clear steps. AM also did not recheck the completed answers, which led to errors in the final results.

The difficulties experienced by AM were likely related to the characteristics of visual learners. AM struggled to understand the questions because they were not accompanied by concrete images or visual representations. This suggests that the absence of visual elements affected AM's comprehension of the problem. If the questions had included Figures or diagrams, AM might have found it easier to interpret and process the information. This finding supports Banggo (2023), who stated that students with visual learning styles tend to comprehend information more effectively when it is presented in the form of images, diagrams, or other visual media. Conversely, they face difficulties when the learning process or questions are presented solely in verbal or textual form.

Sulaiman et al. (2025) further emphasize that visual learners comprehend information more effectively when they are engaged in activities that include visual elements such as reading graphs, tables, and diagrams, especially during mathematical problem solving. Therefore, when problems are presented only in text form without visual support, visual learners like AM may experience difficulties in understanding, planning, and reviewing their solutions.

In this study, the problems were presented in text form, as it was assumed that the descriptions were sufficient to convey the necessary information. However, the results revealed that this approach was less effective for visual learners such as AM. According to DePorter & Hernacki (2011), students with visual learning styles require concrete and visually engaging media to facilitate comprehension and the development of critical thinking skills.

These findings indicate that effective learning for visual learners should be supported by visual aids such as images, diagrams, or tables. Visual media not only help students grasp information more effectively but also assist them in planning, executing, and reviewing their work. Consistent with Hidayat (2024), visual learners perform better when they receive information through visual channels, while they tend to face difficulties in learning processes that lack concrete visual representations.

Problem-Solving Skills of Students with an Auditory Learning Style

Unlike the visual subject, the auditory subject (SF) demonstrated a better understanding of the problems. SF clearly identified the known and unknown information and formulated a solution strategy using the percentage formula. During the interview, SF stated, "I write down what is known, what is unknown, and then look for the solution." However, SF was inconsistent in applying the formula, which resulted in calculation errors. This indicates that SF understood the concepts but lacked accuracy and consistency in execution.

This finding is in line with DePorter & Hernacki (1992), who noted that individuals with an auditory learning style prefer listening to explanations rather than writing. They tend to learn effectively through discussions, verbal explanations, or spoken instructions. Consequently, SF focused more on orally conveyed information and recorded only key points, rather than

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detailing every procedural step. This tendency may cause auditory learners to overlook critical written information necessary for solving mathematical problems completely.

Auditory learners are generally capable of explaining their reasoning coherently when speaking, but they often struggle to document their process systematically. Moreover, they rarely recheck their written work because they rely on memory of what they heard rather than verifying it visually. As a result, they are more prone to overlook minor errors or inconsistencies in their solutions.

Problem-Solving Skills of Students with a Kinesthetic Learning Style

Students with a kinesthetic learning style, such as MR, tended to take concrete actions when solving problems. MR explained that he understood the question by writing down the information first and then immediately performing calculations. As he stated during the interview, "The first step I take is to calculate," while admitting that he did not use alternative strategies. This behavior shows that kinesthetic learners prefer to engage directly in hands-on activities, even though they may not always select the most appropriate formula or operation. MR also mentioned difficulties in remembering formulas and operations, especially multiplication and division, describing them as "remembering formulas, the same as multiplication and division."

The finding that kinesthetic learners performed better on problem-solving tests was supported by interviews with teachers. The mathematics teacher explained that classroom instruction often involved practical simulations, such as buying-and-selling activities or using real objects to illustrate problems. These experiences helped kinesthetic learners better understand concepts through direct engagement. As the teacher stated, "I often ask students to practice the material directly in class. For example, when learning social arithmetic, I ask them to simulate shopping or calculate profits and losses using teaching aids." This aligns with Rosidah et al. (2022), who found that kinesthetic learners are more engaged and successful in active learning environments involving practical activities.

Implications for Teaching Practice

Based on these findings, several strategies can be applied to address the challenges experienced by students with different learning styles. For visual learners, teachers can integrate image-based, animated, or interactive video applications to make learning more engaging (Aulia et al., 2024). For auditory learners, discussion-based or question-and-answer strategies can be used to encourage verbal interaction (Choirunnisa et al., 2025). Meanwhile, for kinesthetic learners, teachers can adopt contextual simulations, collaborative tasks, and hands-on practice with teaching aids. By implementing varied instructional strategies tailored to students' learning styles, teachers can foster more inclusive and effective learning environments. Ultimately, such differentiation can enhance students' mathematical problem-solving abilities across learning style categories.

Conclusion

The results of this study indicate that differences in students' learning styles influence the stages of problem solving as described by Polya. Auditory learners tend to fulfill only certain stages (such as understanding and planning) through verbal comprehension, but they are less consistent in implementation and seldom reflect on their work. In contrast, visual and kinesthetic learners demonstrate more systematic performance across the problem-solving

stages, although their strengths and challenges differ. Visual learners are highly dependent on the presence of images or illustrations and often encounter difficulties when such visual elements are absent. Meanwhile, kinesthetic learners perform better because their active engagement enhances understanding, strategy formulation, implementation, and the habit of rechecking their answers. Therefore, mathematics instruction should be designed adaptively to accommodate the learning style characteristics of each student. For visual learners, the integration of visual elements such as diagrams, images, and interactive media can enhance comprehension. For auditory learners, verbal approaches, explanations, and discussion-based learning can improve understanding and engagement. For kinesthetic learners, the inclusion of concrete activities, hands-on practice, and contextual simulations can foster deeper conceptual understanding. In addition, applying contextual learning that bridges mathematical concepts with real-life experiences can strengthen students' ability to connect theory and practice, thereby improving their problem-solving skills and overall learning outcomes.

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Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

S.A., T.E., H.S.M., and A.R.P. collectively contributed equally to understanding the research ideas, collecting data, drafting the article, and revising and refining the manuscript. The four authors collaborated proportionally in all stages of article preparation. N.I., as the lecturer in charge of the course, played an active role in providing scientific guidance, mentoring during the article preparation process, and revising the content of the article. All authors declare that the final version of this article has been read and approved. The percentage of contribution in the conceptualization, drafting, and correction of this paper is as follows: S.A.: 22.5%, T.E.: 22.5%, N.I.: 10%, H.S.M.: 22.5%, and A.R.P.: 22.5%.

Data Availability Statement

The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [S.A.], upon reasonable request.

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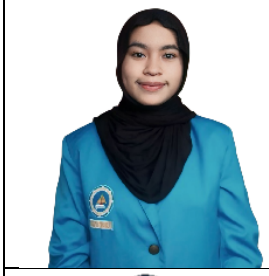	**Susi Andriani,** born in Serasan on January 1, 2004. She began her education at Barunawati Kindergarten in 2009. She then continued her education at SD Negeri 008 Tanjungpinang Timur and graduated in 2016, continuing on to SMP Negeri 4 Tanjungpinang, graduating in 2019. She then continued her education at SMA Negeri 2 Tanjungpinang, graduating in 2022. She is currently pursuing her education at Raja Ali Haji Maritime University, majoring in Mathematics Education. Email: susiandriani.ix.1@gmail.com
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