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Mathematical Thinking Process of Gifted Elementary School Students in Tasikmalaya City: A Case Study

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Abstract

This study aims to describe the mathematical thinking process of gifted elementary school students in Tasikmalaya City in solving mathematical problems that include aspects of conceptual understanding, reasoning, problem solving, representation and mathematical connections. Data were collected through mathematical tests with five higher order thinking skill (HOTS) items, clinical interviews, and direct observations. Scoring reliability between two independent raters showed a high level of agreement (κ = 0.82). Data were analyzed qualitatively through data reduction, categorization, triangulation, and interpretation of emerging patterns. The subjects of the study were ten gifted students identified based on high mathematical ability scores in elementary schools in Tasikmalaya City. Data analysis used a qualitative approach with a case study design through the stages of data reduction to sort out relevant information, data presentation in the form of descriptions and categorization, data triangulation to validate findings from various sources, and drawing conclusions based on patterns that emerge from the data. The findings reveal that gifted students display time efficiency, multiple strategies, and reflective checking behavior in mathematical problem-solving. Of the ten students, one was in the very high category, seven were in the high category, and two were in the medium category. The most dominant indicators were mathematical reasoning and connections, while representation and conceptual understanding showed greater variation. Of the ten students, one student is in the very high category, seven students are in the high category, and two students are in the medium category. Each indicator implies targeted educational support: enrichment tasks for conceptual understanding, structured argumentation exercises for reasoning, open-ended and real-world tasks for problem solving, visual and model-based scaffolding for representation, and interdisciplinary activities for mathematical connections. These findings underscore the need for differentiated, problem-based, and creativity-oriented learning approaches to optimize the potential of gifted students in elementary schools.

Keywords: differentiated learning; elementary school; gifted students; mathematical thinking process

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INTRODUCTION

Mathematical thinking ability is a crucial foundation in elementary education, forming the basis for students' analytical, creative, and problem-solving competencies. Gifted students, in particular, often exhibit rapid conceptual understanding, strategic flexibility, and original problem-solving strategies (Patmawati, 2023; Anaguna, 2019). However, learning practices in elementary schools tend to be uniform, offering limited differentiation that fully accommodates these students' advanced potential (Supratman et al., 2019). This condition is evident in Tasikmalaya City, where several students demonstrate high mathematical aptitude but remain underserved by learning models that recognize their exceptional abilities.

Mathematical thinking involves multiple interconnected aspects—conceptual understanding, reasoning, problem solving, representation, and mathematical connections—that must be cultivated holistically (Saputra, 2024). Previous studies have explored gifted students' creativity or problem-solving in isolation, but few have mapped how each indicator interacts within the overall thinking process (Anaguna, 2019; Sidik, 2020). Understanding these dimensions in gifted learners is essential for designing differentiated and enrichment-based instruction aligned with their cognitive profiles.

Gifted students generally demonstrate excellence in mathematics through sharper analytical skills and creative approaches to solving open-ended and complex mathematical problems (Anaguna, 2019; Patmawati, 2023). This mathematical talent is evident not only in academic grades but also in the mathematical creativity demonstrated when students face unstructured (open-ended) problems. Therefore, understanding the mathematical thinking processes of gifted students is crucial for designing appropriate learning strategies to accommodate their needs (Patmawati, 2023).

Global research increasingly recognizes giftedness as a dynamic capability that can be developed through targeted instructional design rather than as a fixed trait (Renzulli, 2012; Subotnik et al., 2011). In the Indonesian context, however, systematic profiling of gifted students' mathematical thinking—especially using higher order thinking skills (HOTS) tasks—remains scarce. Local studies in Tasikmalaya have mainly emphasized creativity and problem-solving outcomes, without fully connecting quantitative performance data with qualitative evidence from students' reasoning and representations.

In Tasikmalaya City, research related to the mathematical thinking processes of gifted elementary school students is still limited, especially case studies that examine in depth how gifted students process mathematical thinking and solve mathematical problems. Although several studies have examined the mathematical thinking processes of gifted students, there is still a gap in studies that in-depth describe the thinking processes of gifted elementary school students in a local context such as Tasikmalaya, especially through a case study approach with HOTS (Higher Order Thinking Skills)-oriented tasks. Based on the findings of Patmawati (2023), the mathematical creativity of gifted students in Tasikmalaya shows indicators of fluency, flexibility, and novelty, which are important parts of creative mathematical thinking. This creativity must be supported through differential educational programs to optimize the unique potential of each gifted student (Patmawati, 2023).

Creative mathematical thinking in gifted students is also influenced by various internal factors such as confidence and enthusiasm in solving problems, as well as external support from teachers and parents (Anaguna, 2019). However, challenges also arise when a lack of attention and understanding from teachers and parents hinders the development of creative mathematical thinking skills in gifted students (Anaguna, 2019). This suggests that mathematics learning for gifted students needs to be designed not only based on general curriculum standards, but also must consider their unique characteristics and needs.

Mathematical thinking is not only related to problem-solving skills, but also a cognitive process involving various stages such as problem understanding, planning a solution strategy, implementation, and evaluation of results (Saputra, 2024). In the context of 21st-century education, critical, creative, and analytical thinking skills are essential and must be continuously developed from an early age, especially in gifted students who have greater potential in these areas (Irawati, 2025). One effective approach is to implement problem-based learning methods that prioritize active student involvement in solving real-world mathematical problems (Naja & Sao, 2024).

The importance of research on the mathematical thinking processes of gifted students in elementary schools in Tasikmalaya City is crucial for developing learning methods and strategies that are responsive to their needs. Case studies were chosen as the research method because they provide an in-depth and contextualized overview of the mathematical thinking processes and creativity of gifted students, both individually and in groups (Patmawati, 2023; Anaguna, 2019).

Furthermore, the research findings can serve as recommendations for educational policymakers, teachers, and parents in supporting the optimal development of gifted students' potential. With this background, this research is important to provide an empirical picture that can be used as a basis for developing a more targeted differential education program and is able to accommodate the variations in characteristics and learning needs of gifted students, so that it can optimally encourage increased achievement and creativity in mathematics (Patmawati, 2023; Anaguna, 2019).

The research aims to describe gifted students' mathematical thinking processes across five indicators and answer the following questions**:** How do gifted students demonstrate conceptual understanding in solving HOTS-oriented mathematical problems?; What are the characteristics of their mathematical reasoning?; How do they approach problem solving and what strategies emerge?; How are representations used to model and communicate their mathematical ideas?; How do they form mathematical connections between concepts and real-life contexts?

This study focuses on ten mathematically gifted students from public and private elementary schools in Tasikmalaya City, identified through academic achievement and mathematics ability tests. The findings are context-specific and do not generalize to all gifted populations in Indonesia. Data were collected through problem-solving tests, interviews, and observations, which reflect cognitive and behavioral aspects but do not capture emotional or motivational dimensions. Despite these boundaries, the study contributes to a deeper understanding of gifted students' indicator-level thinking profiles and offers empirical implications for designing responsive learning environments.

METHOD

Research Design

This research employed a qualitative multiple embedded case study design (Yin, 2018) to explore in depth the mathematical thinking processes of gifted elementary school students in Tasikmalaya City. Each student was treated as an individual case, and a cross-case analysis was then conducted to identify common and divergent thinking patterns among students (Stake, 1995; Creswell, 2018).

The study was conducted from February to May 2024 in five public and five private elementary schools that were officially recognized by the local education authority as having high-performing students in mathematics. The analysis operated at two levels: (1) within-case analysis to understand the specific thinking characteristics of each student, and (2) cross-case analysis to identify shared patterns and variations across students. This case study approach enabled an in-depth investigation of students' real-life mathematical problem-solving processes and the factors that support their success in learning mathematics (Saputra, 2024; Patton, 2015).

The research flow included the following stages: literature review and problem identification, selection of schools and identification of gifted students, instrument development and validation, data collection (tests, interviews, and observations), data transcription and coding, data analysis and triangulation, and joint display, integration, and interpretation of findings. The overall research flow is summarized in Figure 1.

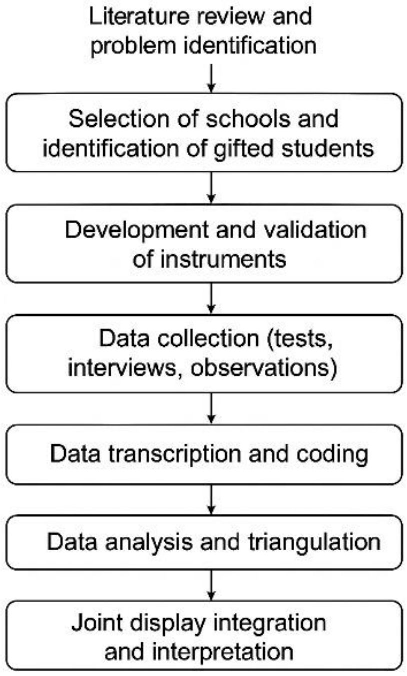

Figure 1. Research Flow

Participant, Sample, or Subject

The research subjects were elementary school students classified as gifted in mathematics. They were selected using academic achievement criteria and a special mathematics ability test in several elementary schools in Tasikmalaya City during the 2023/2024 academic year. These schools had established programs or procedures for identifying gifted students.

A total of 10 students (coded G1–G10) were identified as gifted based on their above-average mathematical thinking abilities. The group consisted of five students from private schools and five students from public schools in Tasikmalaya City. Participant selection followed a multi-stage procedure:

1. School nomination based on mathematics achievement (top 10% of students).
2. Screening using a mathematics ability test (cutoff score ≥ 85/100).
3. Confirmation through teacher recommendations and classroom observations.

The demographic characteristics and selection criteria for each participant are presented in Table 1.

Table 1. Participants

Code	Gender	School Type	Grade	Giftedness Criteria (Cutoff ≥85)	Mathematics Score
G1	F	Private	5	High math test score	90
G2	F	Public	6	Top 10% achievement	87
G3	M	Private	6	High ability test	93
G4	F	Public	5	Top 10% achievement	88
G5	M	Public	6	High math score	91
G6	F	Public	5	Teacher recommendation + test	92
G7	F	Private	6	High math score	95
G8	F	Private	5	High ability test	89
G9	F	Private	6	Top 10% achievement	94
G10	F	Public	5	High math score	86

Instrument and Procedure

Three main instruments were used: a mathematical thinking test, clinical interviews, and participant observations. The mathematical thinking test consisted of five open-ended problems, each representing one key indicator of mathematical thinking:
Q1: Conceptual understanding (even-number series summing to 72)
Q2: Mathematical reasoning (number pattern continuation)
Q3: Problem solving (distribution of 120 oranges)
Q4: Representation (visual proof of the distributive law)
Q5: Mathematical connections (linear model of daily saving)

The problems were designed to be challenging and to allow multiple solution paths, without a single standard answer, to stimulate students' creativity and analytical skills.

Each indicator was scored using a 5-point rubric based on Krulik & Rudnick (1999) and Sumarmo (2013). Each indicator was scored using the criteria that presented in Table 2. The rubric was pilot-tested with 15 non-participant students to ensure clarity and reliability. Two raters (a mathematics education lecturer and an experienced gifted-education teacher) underwent a two-stage calibration process. In Stage 1, they discussed sample student responses (anchor papers). In Stage 2, they independently scored student work and then reconciled differences through consensus. The inter-rater reliability reached $\kappa = 0.82$, indicating strong agreement.

Table 2. Scoring Rubric

Score	Descriptor
5	Complete, accurate, and creative reasoning; consistent representation and reflection
4	Logical and mostly accurate; minor conceptual gaps
3	Adequate understanding; partial reasoning; inconsistent representation
2	Fragmented ideas; major gaps in reasoning or structure
1	Minimal response; irrelevant or incomplete reasoning
0	No attempt or unrelated answer

Data Collection

Data were collected in three sessions for each participant that describe in Table 3 in details. During participant observation, the researcher recorded students' behaviors, expressions, and step-by-step approaches to solving the problems. Documentation included field notes, audio–video recordings, and copies of students' written work, which were used as additional material for analysis. Repeated interviews or observations were conducted when clarification of the data was needed.

All sessions were audio-recorded and video-captured with informed consent. Recordings were transcribed verbatim in Bahasa Indonesia and then translated into English for analysis. Transcription followed a standardized three-step protocol: (a) initial transcription, (b) verification by a second researcher, and (c) anonymization using participant codes (G1–G10).

Table 3. Data collection

Session	Activity
Session 1 – Testing (60 minutes)	Students individually completed the five HOTS problems under observation, providing written responses for each indicator of mathematical thinking.
Session 2 – Clinical Interview (45–60 minutes)	Conducted within one week of testing to explore students' reasoning processes, problem-solving strategies, and reflections

Session	Activity
	on their solutions. Semi-structured questions were used to probe how they understood the problems and why they chose particular strategies.
Session 3 – Observation and Validation (30 minutes)	A follow-up session in which the researcher observed students working on similar mathematical tasks and confirmed the consistency of earlier responses and reasoning.

Measurement Chain and Reliability Procedures

The measurement chain encompassed five indicators of mathematical thinking: (1) conceptual understanding, (2) reasoning, (3) problem solving, (4) representation, and (5) connections. Each indicator was represented by one open-ended problem item. Student responses were rated on a 5-point scale (1 = very low, 5 = very high), using the rubric described in Table 2 and adapted from Krulik & Rudnick (1999) and Sumarmo (2013).

To ensure the reliability of qualitative coding, two coders independently conducted open and axial coding of all transcripts using NVivo 14. Agreement reached $\kappa = 0.82$ (Cohen's Kappa) after discussion of divergent codes, ensuring analytic consistency and transparency. The resulting code tree of mathematical thinking processes is presented in Table 4.

Table 4. Code Tree of Mathematical Thinking Processes

Code	Theme	Description	Example
CU	Conceptual Understanding	Defines how students recognize mathematical relationships	"I used x + (x+2) + (x+4) = 72."
MR	Mathematical Reasoning	Logical inference and rule generation	"The difference increases by 2 each time."
PS	Problem Solving	Strategy planning and execution	"I checked which factors divide 120 evenly."
RE	Representation	Use of symbols, visuals, or diagrams	"I drew 3×9 rectangles and divided them."
MC	Mathematical Connection	Linking math to daily life or other topics	"If I save Rp 2,000 per day, S = 2,000n."

Two coders independently applied this codebook to all transcripts, and the inter-coder reliability reached $\kappa = 0.82$, indicating high consistency.

Ethical Considerations

This research obtained ethical approval from the Ethics Committee of the Community Service Research Institute, Universitas Siliwangi (Approval No. 448/UN58.21/PP/202). Participation was voluntary, and informed consent was obtained from all students and their parents or guardians. All data were anonymized using coded identifiers (G1–G10), ensuring that no personal identity could be traced. All procedures adhered to the ethical standards of the Declaration of Helsinki and the Indonesian National Research Ethics Guidelines.

Data Analysis

The data were analyzed using thematic analysis supported by the interactive model of Miles and Huberman (1994), which involves data reduction, data display, and verification. The steps were as follows (Miles, Huberman & Saldaña, 2014; Braun & Clarke, 2006):

1. ***Data Transcription***: All interview recordings and observation notes were transcribed in full to ensure that no important information about students' thinking processes in solving mathematical tasks was lost.

2. ***Data Coding***: Transcripts were analyzed openly to identify units of meaning relevant to the indicators of mathematical thinking: conceptual understanding, mathematical reasoning, representation, problem solving, and mathematical connections (Sumarmo, 2013; Krulik & Rudnick, 1999). Each unit of meaning was coded and grouped into initial categories (open coding), which were then refined during axial coding.
3. ***Categorization and Theme Mapping***: Codes were grouped into main themes that reflected the mathematical thinking patterns of gifted students, such as problem-solving strategies, creative thinking, and conceptual barriers. These themes were then mapped to illustrate the relationships between concepts and the stages of mathematical thinking.
4. ***Data Triangulation***: Data validity was strengthened by triangulating information from interviews, observations, and documentation (students' written work and field notes) to obtain a consistent and reliable picture of students' mathematical thinking processes.
5. ***Interpretation and Presentation of Results***: The final themes were interpreted to explain the mathematical thinking processes of gifted students, and the findings were presented through descriptive narratives and selected direct quotes. The overall data analysis process, based on Miles and Huberman's interactive model, is illustrated in Figure 2.

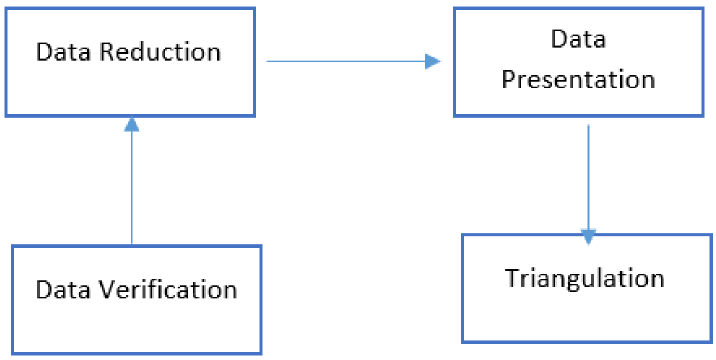

Figure 2. Miles Huberman Data Analysis (Miles & Huberman, 1994)

RESULTS AND DISCUSSION

Overview of Data Sources and Participants

Data for this study were obtained from mathematical thinking tests, in-depth clinical interviews, observations, and documentation of students' written work. The tests were scored using a mathematical thinking process rubric based on Krulik and Rudnick's (1999) indicators. Two independent assessors (a mathematics education lecturer and a teacher experienced in coaching gifted students) scored all test responses. Inter-rater reliability, calculated using Cohen's Kappa coefficient, showed high agreement ($\kappa = 0.82$), indicating that the scoring procedure was consistent and dependable.

The study involved 10 gifted students from ten elementary schools in Tasikmalaya City (both private and public), identified through mathematics ability tests and academic achievement criteria. All participants demonstrated strong verbal and numerical abilities and a high interest in mathematics, consistent with the general characteristics of gifted students described by Reis and Renzulli (2004). They tended to explore problems in depth and were not satisfied with short or superficial answers, showing a reflective and thoughtful mindset (Hollingworth, 2009). These characteristics provided a rich context for analyzing the nuances of their mathematical thinking processes.

Quantitative Profile of Mathematical Thinking Indicators

Table 5 presents the profile of students' mathematical thinking scores across five indicators: conceptual understanding (CU), mathematical reasoning (MR), problem solving (PS), representation (RE), and mathematical connections (MC).

Table 5. Indicator Profiles of Mathematical Thinking Scores

Indicator	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10
CU	4	4	5	4	5	4	5	4	5	3
MR	5	3	4	4	4	5	5	4	5	4
PS	5	4	4	4	5	5	5	4	4	3
RE	4	4	5	5	4	5	5	4	4	3
MC	4	5	5	5	4	4	4	5	5	4
Total score	**22**	**20**	**23**	**22**	**22**	**23**	**24**	**21**	**23**	**17**

Table 6 categorizes the total scores from Table 5 into qualitative levels of mathematical thinking. The total scores of the 10 students range from 17 to 24, indicating that all students are within the High to Very High categories of mathematical thinking. Eight students fall into the Very High category (G1, G3, G4, G5, G6, G7, G8, and G9), while two students (G2 and G10) are in the High category. This pattern confirms that, although all participants were identified as gifted, there is still meaningful variation in the degree of their mathematical thinking sophistication.

Across indicators, mathematical reasoning (MR), problem solving (PS), and mathematical connections (MC) tend to be the strongest dimensions. Most students obtain scores of 4 or 5 on these indicators, suggesting that they can reason logically, plan and execute problem-solving strategies, and link mathematical ideas within and beyond the problem context. Variation is more apparent in conceptual understanding (CU) and representation (RE), where scores range from 3 to 5. For example, G7 shows consistently high scores across all indicators, whereas G10 has lower scores, particularly in CU and RE. This variation indicates that even gifted students may still need targeted support in deepening conceptual structures and improving the clarity of their representations.

Table 6. Score Categories and Descriptions

Score Range	Category	Description
21–25	Very High (Gifted Thinking Level)	Students demonstrate high-level mathematical thinking skills characteristic of gifted learners; they integrate concepts, reasoning, and connections in a reflective and original manner.
16–20	High	Students demonstrate strong logical and strategic thinking skills, with only minor errors.
11–15	Moderate	Students have a basic understanding and general problem-solving strategies, but their thinking is not yet in-depth or flexible.
6–10	Low	Students show limited conceptual understanding, and their strategies are inefficient or incomplete.
1–5	Very Low	Students do not demonstrate relevant mathematical thinking skills.

Joint Quantitative–Qualitative Profiles of Key Cases

To deepen interpretation, quantitative scores were integrated with qualitative evidence from student interviews and observations. Table 7 provides a joint display for four representative students, illustrating how scores align with their expressed reasoning and strategies.

G7's profile illustrates how strong reasoning and connections manifest in practice. The student systematically analyzes differences in a number pattern (4, 6, 8, …) and extends this to 10, 12, and 14, reflecting inductive generalization. This pattern is consistent with gifted students' tendency to search for structure and regularity in mathematical tasks (Reis & Renzulli, 2004).

G3 represents a student with particularly strong conceptual understanding. Their ability to express a problem involving consecutive even numbers using a simple algebraic equation, $x + (x+2) + (x+4) = 72$, indicates comfort with symbolic representation and generalization at an elementary level. This aligns with Saputra's (2024) finding that conceptual understanding serves as a key foundation for more advanced mathematical reasoning.

Table 7. Joint Display of Quantitative Scores and Qualitative Evidence

Student Code	Dominant Thinking Indicator	Quantitative Score	Qualitative Evidence (Representative Quote)	Interpretation
G7	Reasoning & Connections	24 (Very High)	"I checked the pattern difference 4, 6, 8, then I added 10, 12, 14…"	Shows inductive generalization and systematic patterning across cases.
G3	Conceptual Understanding	23 (Very High)	"I use the formula x + (x+2) + (x+4) = 72, then x = 22."	Demonstrates algebraic reasoning at the elementary level and structured conceptual understanding.
G10	Representation	18 (High)	"I draw a rectangle 3×9, divide into two parts 4 and 5."	Shows partial understanding of the distributive property; needs conceptual reinforcement.
G2	Problem Solving	20 (High)	"120 can be divided into 10 bags of 12 oranges each."	Applies factorization in problem solving but shows limited reflection on the generality of the solution.

G10, while still in the High category overall, exhibits relatively weaker conceptual understanding and representation. The student draws a 3×9 rectangle and partitions it into parts 4 and 5 to represent the distributive property. Although this shows an emerging grasp of the concept, the explanation remains partial and suggests the need for further conceptual clarification and support in linking the visual model to the formal statement $3 \times (4 + 5) = (3 \times 4) + (3 \times 5)$.

G2 provides an example of strong problem-solving ability but limited reflection on the generality of solutions. The student correctly identifies 10 bags containing 12 oranges as one possible distribution of 120 oranges, but does not explicitly generalize to the full factor structure of 120. This finding highlights an important instructional implication: even gifted students may benefit from explicit prompts to generalize and systematize their solutions rather than settling for single correct answers.

Overall, the joint display in Table 7 shows that quantitative scores and qualitative evidence are mutually reinforcing. High scores tend to correspond to rich explanations, multiple strategies, and explicit generalizations, whereas lower scores are associated with partial explanations, limited use of representations, or a lack of reflection on the generality of solutions.

Interview-Based Analysis of Mathematical Thinking Processes

To complement the quantitative results, interviews were used to explore how students reasoned through each problem. Table 8 summarizes representative interview excerpts for each test item, illustrating the range of strategies and justifications students employed.

Table 8. Student Interview Results (Representative Excerpts)

Question	Student answers
Give three examples of consecutive even numbers that add up to 72. Explain how you found them.	I started by looking for three consecutive even numbers, for example 20, 22, 24. I added 20 + 22 + 24 = 66, not yet 72. So I tried slightly larger numbers, 22, 24, and 26. If you add them up 22 + 24 + 26 = 72. So that's the answer. "I tried large even numbers, starting from 24, 26, 28. It turned out that 24 + 26 + 28 = 78, too big. Then I shifted to 22, 24, 26. It was exactly 72." "I checked by dividing 72 by two to get 36, from 22 to 26 the total is 72, so that's the answer." "If you add up 20, 22, 24 the result is 66. I tried 24, 26, 28 and the result was 78. Finally, 22, 24, 26 came up with 72." "I imagined three consecutive even numbers, tried starting with 18, 20, 22, but it still wasn't enough. I went up one row until I got 22, 24, 26." "I use the formula x + (x+2) + (x+4) = 72. I calculate x = 22." "I made a table of even number sequences, then tried adding every three numbers until I got the right one." "I use sequential addition: 18 + 20 + 22 = 60, try continuing until 22 + 24 + 26 = 72." "I checked the middle number, 24. Checked 22, 24, 26 and it turned out to be correct." "I look for it by dividing it evenly, for example the average of the three numbers is definitely 24, then the numbers before and after it mean 22 and 26."
The number pattern 2, 6, 12, 20, … is continued, write the next three terms and explain the rules of the pattern.	"I see the difference between the first and second numbers is 4, from 6 to 12 is 6, from 12 to 20 is 8. The difference keeps increasing by 2. So after 20, I add 10, so it's 30. Then I add 12, so it's 42. Then I add 14, so it's 56." "I see the difference between the numbers increasing by 2: 4, 6, 8, so the continuation is adding 10, 12, 14. The answer is 30, 42, 56." "Each term of the pattern is n times (n+1), so the fifth term, n=5, means 5 × 6 = 30; the sixth 6 × 7 = 42; the seventh 7 × 8 = 56."

Question	Student answers
	"The difference pattern increases by 2 each time, 4 then 6 then 8. Then add 10, 12, and 14 to get 30, 42, 56." "The fifth term: 30, the sixth 42, the seventh 56, because the additional pattern is getting bigger." "The next number after 20 plus 10 is 30, plus 12 is 42, plus 14 is 56." "I tried the formula 2, 2+4=6, 6+6=12, 12+8=20, then it became 20+10=30, 30+12=42, 42+14=56." "I checked with the difference pattern, then added two each step. The answer was definitely 30, 42, 56." "I'm looking for a continuous addition system with a constant increment of two." "I see the numbers always increase by two each stage, so the next three numbers are 30, 42, and 56."
A trader has 120 oranges to be divided into plastic bags of equal size. Determine the possible distributions.	"I think the numbers that can divide 120 without a remainder are the factors. For example, 2, 3, 4, and so on. So the bag can be filled with 1 orange to 120 oranges, but it has to be exactly the right number. So there are many possible divisions." "It can be divided into 1 bag of 120 oranges, or 2 bags of 60 oranges each, and so on, all factors of 120." "A possible division is any number that divides evenly into 120, for example 10 bags containing 12 oranges." "I look for factors of 120 and divide them, for example: 20 bags of 6 oranges, 4 bags of 30 oranges." "Try the 120 division table: 1, 2, 3, 4, 5, etc. The result is correct if there are no oranges left over." "All numbers that can divide by 120 can be the number of pockets. The contents depend on the number of pockets." "Multiply various numbers until the times multiplied equal 120. Each result means that it can be divided by the same content." "For example, 6 bags contain 20, 12 bags contain 10, and so on. All combinations without any leftovers." "I made a list of 120 factors and matched them: 1-120, 2-60, 3-40, 4-30, "Find a logical number of pockets so that the oranges contain the same amount; there are

Question	Student answers
	many combinations as long as the product of the pockets and the contents is 120."
Draw a diagram to show that 3 × (4 + 5) = (3 × 4) + (3 × 5)	"I draw a large rectangle with a length of 9 and a width of 3. Then I divide it into two parts; one part is 4 and the other part is 5. So the area is equal to three times 4 plus three times 5." "I made three rows, each row has 9 boxes, then each row is divided into two; 4 boxes and 5 boxes." "There are three groups depicted, each containing four and five boxes added together." "I draw an array of 3 rows and 9 columns, split it into two parts, 4 on the left, 5 on the right." "The large rectangular image is divided into two; one 3×4 area and one 3×5 area." "Making a bar chart, three bars of length 9 are divided into two parts (4 and 5)." "Tree diagram: start from 3, branch to 4 and 5, then add up the totals." "Model image collection, one group of 3 × 4 boxes, one group of 3 × 5 boxes. Add them up." "Imagine a straight array (3 rows, 9 boxes each) so that it can be separated into two groups." "Make a 3-row image, in one row there are 4 or 5 boxes as a dividing line, for a total of 27 boxes."
A student saves Rp 2,000 every day. Write a mathematical model and explain it.	"The model is Rp 2,000 multiplied by the number of days. So if you save for a week, just multiply 7 times 2,000, that's the total savings. You can use it to find out how much money you've accumulated." "The model is S = 2,000 × n, where n is the number of days. If it is 5 days, it means 10,000." The formula is S = 2,000n. So every day it increases by 2,000, n is the day." "The amount of money increases steadily every day, using S = 2,000 × n." "If I write S = 2,000 times the day, for example the 10th day means Rp. 20,000." "Every day n, the amount of savings is 2,000 times n." "S = number of days x 2,000, if you want to know the savings after n days."

Question	Student answers
	"Formula S = 2,000 × n; easy to replace the value of n according to the day." "Mathematical model: S = 2,000 × n; n is the total days of saving, S is the amount of savings."

Conceptual Understanding

Students demonstrate strong conceptual understanding by recognizing even numbers and the relationships between consecutive numbers. Many students move beyond guessing; they use systematic strategies such as adjusting number triples, using averages, or constructing simple algebraic models (e.g., $x + (x+2) + (x+4) = 72$). These approaches show structured thinking and the ability to generalize relationships, consistent with Saputra's (2024) finding that conceptual understanding is a primary foundation for effective mathematical thinking.

Mathematical Reasoning

For the number pattern problem, students carefully analyze differences between terms and recognize a consistently increasing pattern (4, 6, 8, …), which they then extend (10, 12, 14, …). Some students also express the pattern in functional form ($n(n+1)$). These responses reflect effective inductive reasoning, where students derive general rules from specific data. This is in line with Schoenfeld's (2011) definition of mathematical reasoning, which emphasizes the ability to connect steps, justify procedures, and draw logical conclusions within mathematical structures.

Problem Solving

In the orange distribution problem, students identify that the total number of oranges must be divided evenly into bags and recognize that all valid solutions correspond to the factors of 120. They generate multiple factor combinations and interpret each as a different distribution scenario. This demonstrates analytical skills and the transfer of number concepts to real-world contexts, both of which are important aspects of problem-solving ability (Torrance, 2008). Their reasoning about factors also shows creativity in searching for diverse but valid solutions, rather than stopping at a single correct answer.

Mathematical Representation

Students use visual representations, particularly rectangular arrays and bar models, to demonstrate the distributive property of multiplication, $3 \times (4 + 5) = (3 \times 4) + (3 \times 5)$. These visual models make abstract ideas more concrete and highlight the partitioning of an area into two subregions. Such responses reflect visual–spatial thinking, which is essential for understanding and communicating abstract mathematical concepts (Irawati, 2025). The use of representations supports both conceptual understanding and mathematical communication, although some students (e.g., G10) still require guidance to fully connect the visual model with the formal symbolic expression.

Mathematical Connections

In the savings problem, students represent the situation using a linear function, typically $S = 2{,}000n$, where S is the total savings and n is the number of days. They interpret this model correctly by substituting specific values of n (for example, one week or ten days) to find the corresponding savings. This shows that students can connect mathematical expressions with everyday contexts and reason about quantities over time. Such responses align with the concept of mathematical connections, which integrates mathematics with real-life situations and practical applications (Reis & Renzulli, 2004).

Overall, the interview analysis confirms and enriches the quantitative findings. Gifted elementary students in this study do not merely arrive at correct answers; they display a wide repertoire of strategies, show a tendency to generalize patterns, and flexibly move between symbolic, numeric, and visual representations. At the same time, the results highlight areas where even gifted learners benefit from targeted support, particularly in deepening conceptual understanding and making their reasoning and generalizations more explicit.

CONCLUSION

This study examined the higher-order mathematical thinking skills of gifted elementary students in Tasikmalaya across five key indicators: conceptual understanding, mathematical reasoning, problem solving, representation, and mathematical connections. Using an integrated quantitative–qualitative approach, supported by high inter-rater reliability ($\kappa = 0.82$) and joint displays of scores and interview data, the study produced a comprehensive profile of how gifted students think mathematically in real problem-solving situations.

Overall, most students demonstrated strong conceptual understanding. They were able to recognize numerical structures and relationships between consecutive numbers and, in several cases, formulated simple algebraic expressions to represent these relationships. However, some students still relied primarily on empirical trial-and-error strategies rather than on symbolic generalization, indicating that conceptual understanding, although strong, is not uniformly abstract or formal across all gifted learners.

Mathematical reasoning emerged as the most consistently high indicator. Students were generally able to analyze number patterns, recognize regularities, and extend them coherently. Many provided justifications for their answers and articulated the rules underlying the patterns, reflecting the capacity to construct logical arguments rather than merely state results.

In problem solving, students showed effective strategy use, such as factor analysis, decomposition, and the systematic listing of possibilities when working with non-routine tasks. Nevertheless, the depth of reflective evaluation and the flexibility to explore alternative strategies varied among individuals. Some students were satisfied once a single valid solution was found, whereas others checked, compared, and generalized their solutions more thoroughly.

Representation was the indicator with the greatest variability. Several students used clear visual models—such as arrays, rectangular diagrams, and bar representations—to support their reasoning, particularly when illustrating properties like distributivity. Others, including some who were otherwise strong mathematically, tended to rely on mental imagery without translating their thinking into explicit visual or written representations. This limited the clarity and communicability of their ideas and suggests a need to nurture representational fluency even among gifted students.

Mathematical connections were generally well developed. Students were able to relate symbolic expressions, such as simple linear functions, to familiar real-life contexts, including savings and equal sharing. They understood how quantities change over time or across conditions and could interpret these relationships meaningfully, indicating that they were able to connect school mathematics with everyday experiences.

In conclusion, the findings show that gifted students' higher-order mathematical thinking is both advanced and multi-dimensional, yet uneven across indicators. Strong reasoning, problem solving, and connections coexist with variations in the depth of conceptual understanding and the explicitness of representations. These results underscore the need for instruction that is differentiated, representation-rich, and grounded in authentic problem contexts. Learning environments for gifted students should not only accelerate content but also deliberately cultivate flexible strategy use, explicit reasoning, and robust use of multiple representations, so that the full spectrum of their mathematical potential can develop in a balanced and sustainable way.

RECOMMENDATION

This study points to several implications for instructional practice aimed at nurturing higher-order mathematical thinking among gifted elementary students. For conceptual understanding, teachers are encouraged to integrate concept mapping, model construction, and symbolic translation tasks into regular lessons. These activities can help students connect informal ideas with formal mathematical symbols and deepen their grasp of underlying structures.

To strengthen mathematical reasoning, classroom activities should include open-ended inquiries that require students to detect patterns, formulate and test hypotheses, and justify their conclusions. Rich questioning and opportunities for students to explain and critique solutions can further support the development of rigorous argumentation.

With respect to problem solving, instruction needs to emphasize multi-solution tasks that allow for more than one correct strategy or answer. Such tasks can be combined with metacognitive prompts that invite students to plan, monitor, and reflect on their strategies, thereby improving strategic flexibility and self-regulation in solving non-routine problems.

For mathematical representation, teachers should make systematic use of manipulatives, diagramming tasks, digital geometry tools, and other multi-modal modeling activities. These forms of representation enable students to externalize their thinking, move flexibly between visual and symbolic forms, and communicate their ideas more clearly.

To foster mathematical connections, curriculum design should include interdisciplinary tasks that link mathematics with science, financial literacy, and everyday life situations. When students use mathematics to make sense of real phenomena, they are more likely to see the relevance of abstract concepts and to transfer their understanding across contexts.

Future research should explore how gifted students' indicators of higher-order thinking skills evolve over time and in response to specific instructional interventions. Longitudinal studies would provide insight into developmental trajectories and the sustainability of gains in conceptual understanding, reasoning, problem solving, representation, and connections.

Design-based research is recommended to test targeted instructional strategies, particularly those aimed at strengthening representational fluency and explicit reasoning. Comparative studies involving gifted and non-gifted cohorts could clarify the differential effects of enrichment programs and help identify which components are most beneficial for each group. In addition, multi-site studies across different regions of Indonesia would enhance the generalizability of findings and provide an empirical basis for developing national policies and guidelines for gifted mathematics education.

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Een Unaenah		✓				✓	✓	✓	✓	✓	✓	✓		

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

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This research obtained ethical approval from the Ethics Committee of the Community Service Research Institute, Universitas Siliwangi (Approval No. 448/UN58.21/PP/202).

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article.

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