

A Microgenetic Analysis of Students' Statistical Thinking Processes in Solving Grouped Data Decile Problems

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ABSTRACT

This study aims to analyze the development of students' statistical thinking processes in solving grouped-data decile problems through a task-based microgenetic study approach. The study was motivated by students' difficulties in determining decile positions, using cumulative frequency, and understanding the relationship between decile position and decil values. A qualitative method with a task-based microgenetic study approach was employed at SMA Negeri 4 Jayapura during the second semester of the 2025/2026 academic year. The participants were there Grade 11 students purposively selected from 30 students based on diagnostic pretest results, representing high, medium, and low ability categories. The instruments consisted of a diagnostic pretest, microgenetic task sheets, think-aloud guidelines, structured interview guidelines. The findings indicate that students' statistical thinking developed gradually through six phases, culminating in an understanding of deciles as measures of data position. The most prominent change occurred when students began using cumulative frequency as a reference for determining the decile class, which constituted a critical moment in the development of their thinking strategies. The study concludes that the task-based microgenetic study approach is effective for revealing changes in students' strategies and the development of their statistical thinking processes during task completion.

Informasi Artikel

Kata Kunci:

Proses berpikir statistika;
Desil data kelompok;
Task – based microgenetic study;
Critical moment.

ABSTRAK

Penelitian ini bertujuan untuk menganalisis perkembangan proses berpikir statistika siswa dalam menyelesaikan soal desil data kelompok melalui pendekatan task-based microgenetic study. Penelitian ini dilatarbelakangi oleh kesulitan siswa dalam menentukan posisi desil, menggunakan frekuensi kumulatif, serta memahami hubungan antara posisi desil dan nilai desil. Penelitian ini menggunakan metode kualitatif dengan pendekatan task-based microgenetic study yang dilaksanakan di SMA Negeri 4 Jayapura pada semester genap tahun ajaran 2025/2026. Partisipan penelitian terdiri atas tiga siswa kelas XI yang dipilih secara purposive dari 30 siswa berdasarkan hasil tes diagnostik, yang mewakili kategori kemampuan tinggi, sedang, dan rendah. Instrumen penelitian terdiri atas tes diagnostik, lembar tugas mikrogenetik, pedoman think-aloud, dan pedoman wawancara terstruktur. Hasil penelitian menunjukkan bahwa proses berpikir statistika siswa berkembang secara bertahap melalui enam fase, yang berujung pada pemahaman desil sebagai ukuran letak. Perubahan yang paling menonjol terjadi ketika siswa mulai menggunakan frekuensi kumulatif sebagai acuan untuk menentukan kelas desil, yang menjadi critical moment dalam perkembangan strategi berpikir mereka. Penelitian ini menyimpulkan bahwa pendekatan task-based microgenetic study efektif untuk mengungkapkan perubahan strategi dan perkembangan proses berpikir statistika siswa selama penyelesaian tugas.

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1. Introduction

Twenty-first-century education requires students to develop critical and analytical thinking skills as well as the ability to solve problems effectively. In formal education, mathematics plays a strategic role in developing these skills because it encourages students to think logically, systematically, and structurally. Mathematics learning is therefore not only oriented toward mastery of concepts and procedures, but also toward the development of reasoning, communication, representation, and mathematical problem-solving abilities (Ismail et al., 2024; National Council of Teachers of Mathematics, 2000). Statistics is one area of mathematics that contributes to students' ability to collect, present, and interpret data and to use data as a basis for decision-making in various real-life situations (Diyatul Husna et al., 2025).

Although statistics learning plays an important role in developing higher-order thinking skills, various studies indicate that Indonesian students' statistical abilities remain relatively low. According to the Program For International Student Assessment (PISA) 2022 results, Indonesian students' performance in analyzing and interpreting data remained below the international Organisation for economic cooperation and Development (OECD) (2023) average. This condition suggests that the objectives of statistics learning have not yet been fully achieved. One indication can be seen in students' difficulties with measures of position, particularly grouped-data deciles, including determining the decile position, using cumulative frequency, identifying the decile class, and interpreting the resulting decile value (Dewi et al., 2020).

Previous studies have examined students' difficulties in learning statistics. Dewi et al. (2020) reported that students experienced difficulties in understanding measures of position and in applying calculation procedures accurately. This finding is supported by Kusumaningpuri et al. (2022), who found that limited mastery of basic statistical concepts was one of the main factors contributing to errors in solving statistical problems.

Other studies have investigated statistical thinking based on students' characteristics. Qomariyah & Dinarti (2021) found that cognitive style influences students' statistical thinking processes. This finding is supported by Nurul Aini & Kartika Sari (2026), who reported differences in the characteristics of statistical thinking among students with high, medium, and low ability. Diyatul Husna et al. (2025) further showed that students' prior ability influences the strategies they use to solve statistical problems.

In addition, studies by (Amaludin et al., 2023; Ayu et al., 2023; Febrilia et al., 2019) indicate that students' thinking processes in solving mathematical problems, including statistical problems, are influenced by individual characteristics such as ability level and cognitive style. These findings suggest that students may employ different thinking strategies according to their individual characteristics.

Consistent with these findings, Fielding et al. (2025) emphasize that statistics learning should provide opportunities for students to actively interpret data, construct evidence-based arguments, and make decisions based on available information. This

indicates that the development of statistical thinking is not determined solely by mastery of calculation procedures, but also by students' ability to construct reasoning while interacting with data.

Understanding students' thinking processes cannot be adequately achieved by analyzing the final results of task completion alone. To describe how thinking develops during problem solving, a research approach is needed that can capture changes as they occur. One approach is the task-based microgenetic study, which integrates microgenetic design with task-based interviews and enables researchers to observe the development of students' thinking strategies directly during problem solving (Voutsina et al., 2019).

The microgenetic approach was introduced by Siegler & Crowley (1991) as a method for examining cognitive change through intensive observation during development. (Siegler, 2006) identified three main characteristics of the approach: observation during the period in which cognitive change occurs, high observation density or frequency, and in-depth analysis of the change process. (Sherin and Chinn 2022) further explained that microgenetic methods allow researchers to identify small changes in thinking that are often not revealed by conventional research designs and to explain how, when, and why those changes occur during task completion. Copur-Gencturk & Atabas (2024) likewise demonstrated that microgenetic analysis can trace the gradual development of knowledge through intensive observation during learning.

Although previous studies have addressed students' difficulties in statistics, statistical thinking, and the application of microgenetic approaches to various mathematical topics, research specifically examining the development of students' statistical thinking processes in solving grouped-data decile problems through a task-based microgenetic study remains limited, particularly in Indonesia. Moreover, most previous studies have focused on final problem-solving outcomes and have therefore not fully described changes in strategies or the development of students' understanding during task completion. In response to this gap, the present study applies a task-based microgenetic study to reveal the gradual development of statistical thinking among high-, medium-, and low-ability students. This approach makes it possible to identify strategy changes and critical moments that emerge during task completion more comprehensively.

Grouped-data deciles were selected as the focus of this study for several substantive reasons. First, grouped-data deciles require conceptual and procedural understanding simultaneously, including an understanding of frequency distributions, interpolation, and position within a data distribution. Second, previous studies consistently indicate that students experience difficulties with measures of position, including deciles, quartiles, and percentiles, for both ungrouped and grouped data Mediyan et al. (2020). Third, grouped-data decile problems require students to integrate several mathematical concepts and skills, making them an appropriate context for observing the dynamics of statistical thinking across different ability levels.

Based on this background, this study aims to analyze the development of students' statistical thinking processes in solving grouped-data decile problems through a task-based microgenetic study approach. The findings are expected to contribute to research on statistical thinking in mathematics education, expand the use of microgenetic approaches in mathematics education research in Indonesia, and provide a reference for teachers in designing statistics instruction that supports the development of students' thinking processes.

2. Method

This study employed a task-based microgenetic study approach to examine changes in strategies and the development of students' statistical thinking processes while they solved a sequence of grouped-data decile tasks in a single data-collection session. The study did not focus on long-term cognitive development; rather, it examined gradual changes in strategies and understanding that emerged during task completion.

The research procedure consisted of a diagnostic pretest, completion of microgenetic tasks accompanied by think-aloud protocols, and semi-structured interviews. The entire sequence was designed to reveal changes in strategies, the development of statistical thinking, and critical moments experienced by each participant during task completion. Although microgenetic research is often conducted across multiple observation sessions, this study implemented a staged, single-session task-based microgenetic model while maintaining a high density of observations through continuous think-aloud recording and an interview conducted immediately after all tasks had been completed. This design is consistent with the characteristics of microgenetic analysis described by Siegler (2006), enabling detailed observation of changes in students' thinking during task completion.

The study was conducted at SMA Negeri 4 Jayapura during the second semester of the 2025/2026 academic year. The participants were Grade 11 students who had studied grouped-data deciles. Thirty students completed a diagnostic pretest to obtain an initial profile of their ability to solve grouped-data decile problems. Based on the pretest results, students were classified into high-, medium-, and low-ability categories. Three students were then selected through purposive sampling, with S1 representing the high-ability category, S2 the medium-ability category, and S3 the low-ability category.

Selecting three participants from different ability categories was intended to provide a comprehensive description of variations in statistical thinking dynamics during the completion of the microgenetic task sequence, think-aloud protocol, and semi-structured interview. The data consisted of students' written responses, think-aloud recordings, and interview results. These data were analyzed using a microgenetic approach to trace strategy changes, the development of statistical thinking processes, and the critical moments that emerged during task completion.

Tabel 1 Research Stages

Stage	Activity	Data Obtained
1.	Diagnostic pretest for 30 students	Student's initial understanding of grouped-data deciles

2.	Selection of research participants (S1, S2, S3)	High, medium, and low ability categories
3.	Completion of microgenetic tasks accompanied by think-aloud	Students' statical thiking processes during task completion
4.	Semistructured interview	Students' explanations of the steps, reasons, and conceptual understanding used
5.	Microgenetic analysis	Development of statistical thinking and critical moments emerging during task completion

The study used four types of instruments: a diagnostic pretest, microgenetic task sheets, think-aloud guidelines, and semi-structured interview guidelines. The microgenetic task sheet contained four sequential tasks: (1) completing a cumulative-frequency distribution table, (2) determining the decile position, (3) identifying the decile class, and (4) calculating the decile value using an interpolation formula. The four instruments were designed to reveal changes in strategies and the development of statistical thinking at each stage of task completion. Before use,

all instruments underwent expert judgment involving two mathematics education lecturers and one senior high school mathematics teacher.

Data were obtained from the diagnostic pretest, students' written responses, think-aloud recordings, and semi-structured interview transcripts. While completing the tasks, each participant was asked to verbalize their thoughts and steps so that the thinking process could be observed directly. All activities during task completion were video-recorded and subsequently transcribed for analysis. After the complete sequence of tasks, semi-structured interviews were conducted to clarify the strategies, reasons, and development of the statistical thinking demonstrated by each participant. Data credibility was established through technical triangulation by comparing written work, think-aloud recordings, and interview results.

Data analysis followed six microgenetic stages. First, all data from the think-aloud sessions and interviews were transcribed. Second, the task-solving process was divided into episodes corresponding to stages of solving the grouped-data decile problems, including determining the amount of data and determining the decile position. Third, the forms of understanding demonstrated by students in each episode were identified. Fourth, changes in strategies and the development of statistical thinking during task completion were analyzed. Fifth, critical moments, defined as moments indicating important changes in students' thinking processes, were identified. Finally, written responses, think-aloud recordings, and interview results were triangulated to ensure consistency and credibility of the findings.

The findings were presented descriptively to explain the development of each participant's statistical thinking, the characteristics emerging at each stage, and the microgenetic

trajectory showing changes in strategies and thinking during task completion.

3. Results and Discussion

3.1. Diagnostic Pretest Results and Participant Selection

The diagnostic pretest was administered to all students to determine their initial ability to solve grouped-data decile problems. Based on the scores, students were classified into three ability categories, as shown in Table 2.

Table 2 Distribution of Students' Ability Based on the Diagnostic Pretest

Category	Number of Students
High	18
Medium	5
Low	7
Total	30

Based on this classification, three participants were selected through purposive sampling, each representing one ability category: S1 represented the high-ability category, S2 the medium-ability category, and S3 the low-ability category. The characteristics of the three participants are presented in Table 3.

Table 3. Characteristics of Research Participants

Participant	Pretest Score	Category
S1	90	High
S2	70	Medium
S3	50	Low

The three participants with different levels of cognitive ability were selected to enable an in-depth comparison of the dynamics of their statistical thinking during the solution of grouped-data decile problems.

The pretest results showed variation in students' initial ability to solve grouped-data decile problems. These differences formed the basis for participant selection because the task-based microgenetic study focused on detailed observation of the development of thinking within each ability category. Selecting students representing high, medium, and low ability made it possible to examine and compare the development of statistical thinking demonstrated by each participant throughout the

sequence of tasks.

3.2. Statistical Thinking at the Stage of Determining the Decile Position

At the initial stage, students were asked to determine the position of D6 for the grouped data presented in the problem. The analysis revealed substantial differences in the thinking processes of the participants.

Table 4. Characteristics of Students' Thinking at the Decile-Position Stage

Participant	Characteristics of Thinking Process
S1	Determines the decile position correctly using the formula and understands the meaning of the calculated result.
S2	Determines the decile position correctly using the formula, but has not yet fully understood the meaning of the result.
S3	Interprets the calculated decile position as the decile value.

All three participants were able to operate the decile formula, but they differed fundamentally in how they interpreted the result. S3's written work indicated a conceptual disconnection: although the calculation procedure was correct, the participant immediately treated the resulting position as the decile value. This was confirmed through the interview.

4. Tentukanlah nilai desil ke-6 (D_6) !
Jawab :
$$D_6 = \frac{6}{46+1} \cdot \frac{246}{10} = 24,6$$

Gambar 1 S3's response at the stage of determining the decile position.

Analysis of S3's work (Figure 1) indicates a conceptual disconnection. Although the participant was able to apply the decile-position formula procedurally, the calculated position was interpreted as the final decile value. This suggests that S3 had not yet understood the decile position as an indicator used to locate data within the frequency distribution.

The interview results showed that S3 still held a misconception about the meaning of the decile position.

P : "What does the number 24.6 from your calculation mean?"

S3 : "24.6 is the decile value."

This exchange indicates that S3 had not yet understood the role of the decile position as an indicator of data location within a frequency distribution. The participant's thinking was still dominated by a procedural orientation: the calculation was performed without a corresponding conceptual understanding of the meaning of the result. This condition is consistent with a tendency in statistics learning to prioritize formula mastery, which can lead students to memorize solution steps without constructing meaningful understanding.

This finding is consistent with Dewi et al. (2020), who reported that students' errors in solving problems involving measures of position are related not only to procedural mistakes but also to inadequate conceptual understanding. The finding also supports Kusumaningpuri et al. (2022), who explained that limited mastery of basic statistical concepts encourages students to rely more on memorized solution steps than on understanding the purpose of each procedure. In the present study, S3 still interpreted the calculated decile position as the decile value and therefore did not recognize that the position is used to locate the relevant class before the actual decile value is calculated.

In contrast to S3, S1 demonstrated a more accurate understanding of the function of the decile position.

P : "What does the number 24.6 from your calculation mean?"

S1 : "It indicates data position 24.6. To determine the decile class, I need to look at the cumulative frequency again."

The interview indicates that S1 correctly understood the function of the decile position as an indicator of data location within the frequency distribution. S1 understood that the calculated position was not yet the decile value, but rather a reference for determining the decile class using cumulative frequency. This suggests that S1's thinking had developed toward conceptual understanding, whereas S3 still tended to apply procedures without understanding the relationship among the decile position, decile class, and decile value.

The difference between S1 and S3 shows that students' characteristics and prior ability play a role in determining the strategies used to solve statistical problems. This finding is consistent with Qomariyah and Dinarti (2021), who explained that statistical thinking is influenced by student characteristics, and with Diyatul Husna et al. (2025), who reported that prior ability contributes to strategy selection in solving statistical problems. In this study, the high-ability student was able to use the decile position and cumulative frequency to determine the decile class accurately, whereas the low-ability student experienced difficulty distinguishing the decile position from the decile value and therefore remained more procedurally oriented.

3.3. Development of Statistical Thinking in Using Cumulative Frequency

After determining the decile position, participants were asked

to identify where that position fell within the frequency-distribution table. This stage represented the most significant critical moment in the study. The characteristics of each participant's understanding are presented in Table 5

Table 5 Characteristics of Students' Thinking in Using Cumulative Frequency

Participant	Characteristics of Thinking Process
S1	Uses cumulative frequency systematically to determine the location of the decile position.
S2	Uses cumulative frequency while rechecking the data position.
S3	Initially experiences difficulty determining the decile position, then begins to use cumulative frequency.

As shown in Table 5, the most prominent difference occurred in S3. The participant did not initially understand the relationship between the decile position and cumulative frequency and tended to stop after obtaining the calculated decile position. Development in S3's understanding emerged when the participant recognized that data position 24.6 had to be confirmed using the frequency-distribution table.

3. Lengkapi table frekuensi kumulatif dibawah ini!

Nilai	Frekuensi	Frekuensi Kumulatif
31-35	4	4 ...
36-40	6	10 ...
41-45	8	18 ...
46-50	10	28 ...
51-55	6	34 ...
56-60	4	38 ...
61-65	2	40 ...

Karena 24,6 ada diantara 18 dan 28
Jadi letak dari D₆ adalah pada kelas nilai 46-50

Gambar 2 S3's response at the stage of locating the decile position

Figure 2 shows the development of S3's thinking when the participant began to use cumulative frequency to locate the decile position. S3 compared data position 24.6 with the cumulative-frequency values for each interval and identified that the position lay between cumulative frequencies 18 and 28. Based on this comparison, S3 concluded that the decile position was located in the 46–50 interval.

The interview showed that S3 was able to determine the decile location using cumulative frequency as a reference.

P : "Why did you look at the cumulative frequency?"

S3 : "Because I need to know which class contains data position 24.6."

This exchange shows that S3 began to recognize the role of cumulative frequency as the basis for locating the decile within a frequency distribution.

In contrast, S1 demonstrated a more structured line of reasoning when using cumulative frequency.

P : "How did you determine the location of the decile?"

S1 : "I found data position 24.6 and then compared it with the cumulative frequencies. Because the position lies between 18 and

28, the appropriate decile class is 46–50.”

This interview indicates that S1 understood the function of cumulative frequency in determining the decile class rather than merely using it as a procedural step. S1 was able to conceptually connect the decile position with cumulative frequency, resulting in a more systematic determination of the decile class.

Comparing the responses of S1 and S3 shows that both participants used cumulative frequency as a reference for locating the decile position. However, S1 was able to explain the relationship between the decile position and cumulative frequency more systematically, whereas S3 remained focused on finding the class containing the data position. This indicates a development in statistical thinking from simply identifying the location of data toward a deeper understanding of the role of cumulative frequency in determining the decile class.

The findings indicate that the development of statistical thinking occurred gradually. At the previous stage, participants still interpreted the decile position as the final output of a calculation. At this stage, they began to recognize that the decile position functions as an indicator of data location within a frequency distribution. From a microgenetic perspective, this shift from a focus on calculation results toward understanding the location of data represents a conceptual cognitive change that developed gradually during task completion.

S3’s difficulty at the cumulative-frequency stage may be related to the high cognitive load experienced by the participant. S3 had to process the concept of data position, the structure of the frequency-distribution table, and the meaning of cumulative frequency simultaneously. These three concepts had not yet been fully integrated into the participant’s cognitive schema, increasing the processing burden during task completion. This interpretation is consistent with cognitive load theory, which proposes that the processing of new information can be hindered when working-memory capacity is exceeded Sweller (1988).

The findings at this stage are also consistent with Qomariyah & Dinarti(2021), who reported that statistical thinking is influenced by student characteristics. In the present study, this influence became visible when students began to use cumulative frequency as a reference for locating the decile position. The findings also support Diyatul Husna et al.(2025), who found that prior ability contributes to the strategies students use in solving statistical problems. Students with stronger initial understanding tended to apply more systematic strategies during task completion.

3.4. Statistical Thinking at the Stage of Applying the Decile Formula

After the decile class had been identified, the participants were asked to calculate the decile value quantitatively by applying the grouped-data decile formula.

Table 6 Students’ Thinking About the Components of the Grouped-Data Decile Formula

Component	S1	S2	S3
L	Understands L as the low	Understands L as the lower	Identifies its value from the

	er boundary/ start point o f the interval containing the decile position.	class boundary, but does not always relate it to the decil position.	table, but does not yet understand its function.
F	Understands F as the cumulative frequency before the decile class.	Understands its function and rechecks it.	Describes it as “the number used for calculation” without understanding its meaning.
f	Understands f as the number of data points in the decile class.	Understands f as the frequency of the decile class.	Identifies it as the frequency of the decile class but cannot explain its specific role.
c	Understands c as the class interval range.	Understands c as the class width.	Knows how to calculate it but does not yet understand why it is used.

The following interview illustrates S3’s thinking in understanding the F and f components of the decile formula.

P: “What does F mean in the formula?”

S3: “The number used for calculation.”

P: “What does f mean in the formula?”

S3: “The frequency of the decile class?”

The interview indicates that S3 had not fully understood the function of each component in the decile formula. Although the participant could apply the formula to obtain a numerical result, the understanding of the role of each component remained incomplete. S3’s thinking about the formula components was therefore partial: the participant could apply the procedure but could not fully explain the function of each component. This indicates that obtaining a correct answer does not necessarily reflect deep conceptual understanding.

This finding is consistent with Mediyani et al.(2020), who reported that students can often follow solution procedures correctly while still experiencing difficulties understanding the underlying concepts. Therefore, statistics instruction should not focus solely on procedural mastery but should emphasize the relationship between each formula component and the concept of measures of position so that students understand the rationale underlying each solution step.

3.5. Microgenetic Trajectory of Students’ Statistical Thinking

The analysis showed that students’ thinking developed through six interconnected phases.

Table 7 Microgenetic Trajectory of Statistical Thinking

Phase	Characteristics of Thinking Process

1	Students interpret the decile solely as the final result of the calculation.
2	Students begin to understand that a decile represents a data position within a frequency distribution.
3	Students use cumulative frequency as a reference during problem solving (critical moment).
4	Students identify and determine the interval class containing the decile position.
5	Students apply the grouped-data decile formula to calculate the decile value quantitatively.
6	Students achieve a conceptual understanding of the decile as a measure of position in a data distribution.

Based on Table 7, statistical thinking developed through a series of interconnected stages, beginning with interpreting the decile as a calculation result and progressing toward understanding the decile as a measure of data position. This development reflects changes in students' understanding of the decile concept during task completion.

To clarify the developmental stages identified in Table 7, Figure 3 presents a visualization of the microgenetic trajectory showing changes in students' thinking during task completion.

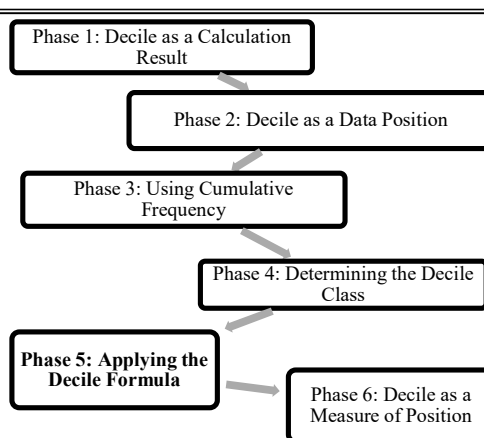


Figure 3 Microgenetic trajectory of students' statistical thinking

Figure 3 shows that students' statistical thinking during the grouped-data decile tasks developed gradually. The development was characterized by a shift from an understanding focused on calculation procedures toward a conceptual understanding of the decile as a measure of data position.

As shown in Figure 3, students' statistical thinking underwent a series of gradual and continuous changes during task completion. The most prominent change occurred when students began to use cumulative frequency as a reference for determining the decile position. This stage constituted a critical moment marking a shift in thinking strategy from mechanical procedural application toward a conceptual understanding of the decile as a measure of data position.

The responses of S1 and S3 show differences in the development of statistical thinking. S1 was able to use cumulative frequency systematically to determine the decile position, whereas S3 required a gradual process to connect the decile position with cumulative frequency and the decile class. This suggests that the use of cumulative frequency functioned as a critical moment that prompted a change in students' thinking strategies.

This finding is consistent with the characteristics of the microgenetic approach, which emphasizes observation of small changes occurring during learning. The development observed in the students did not occur abruptly, but rather through interconnected stages that could be examined in detail during task completion. This is consistent with Siegler (2006), who argued that cognitive development proceeds gradually through shifts from less effective strategies toward more effective strategies.

The findings are also consistent with Qomariyah and Dinarti (2021), who found that statistical thinking is influenced by individual student characteristics. The different developmental trajectories of S1, S2, and S3 indicate that initial ability plays a role in determining the strategies used during task completion. This finding also supports Diyatul Husna et al. (2025), who reported that students' initial ability contributes to strategy

selection in solving statistical problems.

Overall, the findings show that students' statistical thinking in solving grouped-data decile problems developed gradually through strategy changes during task completion. The development was characterized by a shift from a procedural orientation toward a conceptual understanding of the decile as a measure of data position. The findings further indicate that using cumulative frequency was a critical moment that prompted changes in students' thinking strategies for determining the decile class and decile value. In addition, the differences in developmental trajectories demonstrate that the task-based microgenetic study can reveal dynamics of strategy change that cannot be observed solely by analyzing final problem-solving outcomes.

4. Conclusion and Recommendations

This study aimed to analyze the development of students' statistical thinking processes in solving grouped-data decile problems through a task-based microgenetic approach. The findings show that students' statistical thinking developed gradually through six interconnected phases: interpreting the decile as a calculation result, understanding the decile as a data position, using cumulative frequency, determining the decile class, applying the decile formula, and understanding the decile as a measure of data position. This development occurred gradually through observable strategy changes during task completion.

The study also revealed that the use of cumulative frequency constituted a critical moment marking a shift in students' thinking strategies from a calculation-oriented procedural approach toward a conceptual understanding of the decile as a measure of data position. In addition, the developmental trajectories differed across ability categories. The high-ability student tended to demonstrate more systematic strategies from the beginning, whereas the low-ability student developed strategies gradually before reaching conceptual understanding.

These findings imply that statistics instruction should not focus only on mastery of calculation procedures but should also facilitate the development of conceptual understanding through activities that encourage students to explain the reasons, strategies, and thinking processes underlying their solutions. The task-based microgenetic approach contributes to explaining how, when, and why changes in statistical thinking occur during task completion, thereby enriching mathematics education research concerned with the development of students' thinking processes.

Based on the findings, teachers are encouraged to emphasize the relationships among the decile position, cumulative frequency, decile class, and decile value before introducing the decile formula. Instruction should also be designed to provide students with opportunities to articulate the reasons, strategies, and thinking processes they use when solving statistical problems. In this way, the development of students' statistical thinking can be supported more effectively.

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