JIPP

https://journal.upgriptk.ac.id/index.php/JIPP/index
ISSN 2962-3081

Journal Inovasi Pendidikan dan Pengajaran

THE MATHEMATICAL THINKING PROFILES OF JUNIOR HIGH SCHOOL STUDENTS AT SMP NEGERI 1 SUKADANA IN SOLVING HIGHER ORDER THINKING SKILLS (HOTS) PROBLEMS ON STATISTICS

Sulastriani[1], Syarifah Fadillah Al - Hadad[2], Buchari[3]

[1] Universitas PGRI Pontianak, Pontianak, Indonesia
[2] Universitas PGRI Pontianak, Pontianak, Indonesia
[3] Universitas PGRI Pontianak, Pontianak, Indonesia

*Email: sulastriani454@gmail.com

Abstract: Mathematical thinking is a critical cognitive skill that enables students to interpret, analyze, evaluate, and draw conclusions when solving mathematical problems, particularly those demanding higher-order reasoning. In statistics learning at the junior high school level, students commonly show considerable variation in their mathematical thinking processes, especially when interpreting statistical data and determining appropriate solving strategies for Higher Order Thinking Skills (HOTS) problems. This study aimed to analyze the mathematical thinking profile of eighth-grade students at SMP Negeri 1 Sukadana in solving HOTS problems on statistics, focusing on their ability to identify given and asked information, select relevant concepts or formulas, arrange systematic solution steps, and verify and conclude their answers. A qualitative descriptive method with a case study design was used. Data were collected through diagnostic tests and in-depth interviews with six students purposively selected from class VIII G, representing high, moderate, and low mathematical-ability categories (two students per category); the test instrument was validated by two mathematics education lecturers and one subject teacher, and data credibility was ensured through triangulation. The results showed distinct differences in mathematical thinking profiles across ability levels. High-ability students accurately identified problem information, selected correct concepts, constructed systematic and logical solution steps, and consistently verified their answers. Moderate-ability students understood most of the given information but had difficulty fully interpreting the problem and made minor procedural errors. Low-ability students frequently failed to identify complete information, applied incorrect concepts, made computational errors, and rarely re-checked their final answers. Overall, the findings indicate that the higher a student's mathematical ability, the more systematic and complete their thinking process in understanding, planning, executing, and evaluating solutions to statistics-based HOTS problems. These findings suggest that teachers should strengthen contextual, story-based problem practice, habituate systematic solution-writing, and emphasize answer-checking strategies to improve students' higher-order mathematical thinking in statistics..

Keywords: mathematical thinking profile; Higher Order Thinking Skills (HOTS); statistics; case study; junior high school students

Introduction

Mathematical thinking is a fundamental cognitive skill that underlies students' success in learning mathematics, as it enables them to interpret, analyse, evaluate and draw conclusions when confronted with

mathematical problems (Kusuma Dewi et al., 2020). A profile is generally understood as a picture, illustration, chart or overview that presents specific facts about a person or condition (Kamus Besar Bahasa Indonesia, 2017; Neufeld, as cited in Kristanto, 2019), and when applied to learning, a profile describes in detail the potential possessed by each individual student (Aritonang, 2017; Rahmawati, 2019). Building on this notion, a mathematical thinking profile can be defined as the characteristics of students' thinking processes, encompassing critical, creative and systematic reasoning when dealing with mathematical problems (Miatun & Nurafni, 2019). Such a profile is expressed not only through internal cognitive activity but also through observable behaviour, such as the way students present their solution steps, record their responses and justify the solutions they propose (Hodiyanto, 2017).

Mathematics learning in schools has traditionally tended to emphasise mathematics as a finished product rather than as a process of thinking, so that classroom activities have focused more heavily on procedural drill than on the development of deep conceptual understanding (Kusaeri, 2017). This is problematic because mathematical thinking is an essential skill that supports learning outcomes (Land, Tyminski, & Drake, 2019) and serves to help students study the world around them by identifying patterns and relationships between different objects and phenomena (Sabirova, Fassakhova, & Sadykova, 2020). Mathematical thinking ability can further be understood as a thinking process that involves gathering, analysing and synthesising information in order to build new understanding (Layyina, 2018). Consequently, mathematical thinking is a key element for constructing new knowledge in a coherent manner, mastering concepts, solving everyday contextual problems, and improving learning achievement.

One instrument commonly used to measure higher-order thinking is the Higher Order Thinking Skills (HOTS) problem, which assesses reasoning that goes beyond mere recall, restatement or unprocessed reference (Kementerian Pendidikan dan Kebudayaan [Kemendikbud], 2017). In an assessment context, HOTS problems specifically measure five abilities: transferring one concept to another, processing and applying information, connecting different pieces of information, using information to solve problems, and critically examining ideas (Betha et al., 2018; Kemendikbud, 2017). HOTS problems are not necessarily more computationally difficult than recall-type problems; rather, non-routine problems that require more than one procedure and are grounded in real phenomena can train students to develop mathematical literacy (Suyitno et al., 2018) and are typically contextual, based on real-life situations rather than purely theoretical conditions (Sani, 2019).

Statistics is defined as the science of collecting, presenting, analysing and interpreting data to support decision-making (Montgomery, 2020), and as the scientific method used to process data so that it produces meaningful information across fields such as education, economics and social research (George, 2021). It is also described as a set of techniques for organising, summarising and drawing conclusions from data obtained through research (Witte, 2020), and its practical value has been demonstrated in countries such as Japan, which has applied probability theory to successfully market domestically manufactured products (Boediono & Koster, as cited in Nisa & Susanti, 2019). Statistics is taught as one of the core topics in junior high school mathematics, requiring students not merely to perform numerical computation but also to interpret data and draw logical inferences within real-world contexts.

A preliminary study conducted with students of SMP Negeri 1 Sukadana revealed that, although students were generally able to determine class midpoints, compute the mean and calculate percentages, their problem-solving process remained largely procedural and mechanical. Students tended to apply formulas directly without offering conceptual explanations for their steps, and they rarely demonstrated reflective abilities such as justifying the rounding of results, interpreting the meaning of the mean within the context of the problem, or re-checking their answers. These findings indicate that students' mathematical thinking was still at an operational-procedural stage and had not yet reached the analytical-reflective stage that characterises higher-order thinking. At the classroom level, students of SMP Negeri 1 Sukadana also display considerable heterogeneity in academic ability, learning style, confidence and mathematical communication, which is reflected in varying degrees of accuracy and quality when solving HOTS problems on statistics. Some students can interpret tabular, bar-chart and pie-chart data, determine the mean, median and mode, and draw systematic and logical conclusions, whereas others still struggle to understand the intent of a problem, interpret statistical data, and select an appropriate solving strategy. This variability indicates that not all students are equally able to analyse, interpret and draw accurate conclusions when facing contextual statistical problems, underscoring the need for an in-depth study of how students actually think when solving such problems.

Based on this background, the present study aims to analyse the mathematical thinking profile of students of SMP Negeri 1 Sukadana in solving Higher Order Thinking Skills problems on statistics. Specifically, the study seeks to analyse students' ability to (1) recognise and determine the information given and asked in HOTS problems on statistics, (2) select and determine the appropriate statistical concepts or formulas for solving HOTS problems, (3) arrange the steps required to solve HOTS problems on statistics, and (4) re-check the accuracy of their answers and draw conclusions from their solutions to HOTS problems on statistics.

Methodology

Research Design

This study employed a qualitative approach with a descriptive method. According to Sugiyono (2016), qualitative research is a method used to examine natural object conditions in which the researcher acts as the key instrument, and the descriptive approach involves collecting data in the form of words and pictures rather than numbers (Maleong, 2018). This approach was selected because the study sought to describe in depth the mathematical thinking profile of students in solving Higher Order Thinking Skills (HOTS) problems on statistics. The research was conducted under natural classroom conditions, with the researcher serving as the primary instrument in collecting data through tests, interviews and documentation. The form of research applied was a case study, defined as an investigation of an event, situation or social phenomenon that aims to reveal the distinctive characteristics of the case under study (Harahap, 2020). Through a case study design, the researcher was able to explore in detail students' thinking processes, the characteristics that emerged at each stage of problem-solving, and the factors influencing how students understood and completed the given tasks.

Population and Research Subjects

The study was conducted at SMP Negeri 1 Sukadana, Kayong Utara Regency, West Kalimantan, involving students of class VIII G in the 2025/2026 academic year. This class was selected because the students had studied or were studying statistics in accordance with the applicable curriculum, and the mathematics teacher fully supported the implementation of the research in this class. Research subjects were determined using purposive sampling, defined as a sampling technique based on particular considerations or criteria (Sugiyono, 2018). Subject selection was carried out in several stages, namely administering a diagnostic test to all students of class VIII G, analysing the test results based on indicators of mathematical thinking, and considering students' ability to communicate their thinking processes orally and in writing. Based on the test results, students were grouped into three ability categories—high, moderate and low—and two students were selected from each category, resulting in a total of six research subjects. This selection was intended to provide a comprehensive picture of students' mathematical thinking profiles across all ability levels. The criteria applied in determining the subjects included: (1) the ability to communicate their thinking process adequately, both orally and in writing; (2) willingness to participate as a research subject throughout the entire data collection process; (3) representation of the high, moderate and low ability categories based on the test results; and (4) recommendation from the subject teacher as representative of the general characteristics of classroom learning.

Data Collection Technique

Data were collected using a measurement technique and a direct communication technique. The measurement technique involved administering a diagnostic test to determine students' errors and thinking processes in solving HOTS problems on statistics (Sugiyono, 2018), with raw scores converted into standardised values. The direct communication technique was carried out through semi-structured interviews, defined as a data collection method involving direct contact between the researcher and the students through face-to-face conversation (Isnaini, 2013). Interviews were conducted after the test to confirm the accuracy and consistency of students' answers, during which students were asked to explain the reasoning behind their answers and to describe the difficulties they encountered while working on the problems.

Research Instrument

Two instruments were used in this study: a written test and an interview guide. The test consisted of essay-type HOTS problems on statistics, developed through curriculum analysis, textbook analysis, the preparation of a test blueprint, and item writing. The instrument was validated in terms of content by two mathematics education lecturers from Universitas PGRI Pontianak and one mathematics teacher from SMP Negeri 1 Sukadana, all of whom confirmed that the test items were suitable for use. Item validity was calculated using the product-moment correlation technique (Lestari & Yudhanegara, 2015), and all four items met the sufficient-validity criterion ($r_{xy} \geq 0.40$). The reliability of the instrument was calculated using the same reference (Lestari & Yudhanegara, 2015) and yielded a coefficient of 0.966, indicating a very high level of reliability. The interview guide, developed as a semi-structured protocol (Sugiyono, 2018), was likewise validated by two mathematics lecturers and one subject teacher and was declared suitable for obtaining general information about students' errors in completing statistics problems.

Data Analysis Technique

Data analysis is the process of systematically searching for and organising data obtained from interviews and field notes by breaking the data into units, synthesising them, arranging them into patterns, selecting what is important, and drawing conclusions that can be readily understood (Sugiyono, 2018). Analysis in this study was conducted qualitatively and descriptively, following the interactive model of Miles and Huberman (as cited in Sugiyono, 2018), which comprises three stages: data reduction, data display and conclusion drawing. Data reduction involved processing the written test results, grouping students according to their ability level (high, moderate, low), and transcribing the verbal data obtained from the interviews. Data display was carried out in narrative form, as this format facilitates readers' understanding and interpretation of the processed data (Rijali, 2018) and allows the researcher to present field information in a coherent and contextual manner (Haki & Prahastiwi, 2024). Conclusions were drawn by comparing the written test results with the

interview data and relating these findings to relevant theories, producing an in-depth description of students' mathematical thinking profiles in solving HOTS problems on statistics. To ensure the credibility of the data, this study applied technique triangulation (Sugiyono, as cited in Pratiwi, 2017), comparing the data obtained from the written essay test on statistics with the data obtained from student interviews, so that the accuracy of the findings was verified through more than one complementary data collection technique.

Results and Discussion

The diagnostic test was administered to 23 students of class VIII G, each item carrying a maximum score of 12 for items 1 and 2 and 9 for items 3 and 4, giving a maximum total score of 42. The results showed a wide spread of achievement: the highest score (42) was obtained by one student who answered every indicator correctly, whereas five students scored 0, failing to satisfy a single indicator. The mean score declined consistently as the item number increased 6.00 for item 1, 4.57 for item 2, 2.87 for item 3 and 2.35 for item 4 indicating that cognitive demand rose progressively from items requiring routine computation of the grouped mean (items 1–2) to items requiring synthesis of a combined mean (item 3) and evaluation of the grouped median (item 4). Based on the established scoring criteria, students were distributed into three categories: 4 students (17.4%) high, 13 students (56.5%) moderate, and 6 students (26.1%) low. This distribution shows that mathematical thinking ability in solving HOTS problems on statistics was dominated by the moderate category, reflecting that most students possessed only a basic understanding without consistently satisfying every indicator of higher-order thinking, while the relatively small high-ability group indicates that genuine higher-order mathematical thinking remains uncommon in this class.

Six students two from each ability category were subsequently examined in depth through their test work and interview transcripts. Their mathematical thinking profiles were analysed using Polya's (1973) problem-solving stages and classified according to Newman's (1977) error categories: reading, comprehension, transformation, process-skill and encoding errors. In the problem-understanding stage, high-ability students accurately translated the tabular and diagrammatic stimuli into a mathematical model and were free of comprehension errors, whereas low-ability students experienced severe comprehension errors, particularly on items 3 and 4, and admitted during interviews that they were unable to determine what the problem was actually asking, so that their thinking process stalled before it began. In the planning stage, high-ability students correctly selected and transformed the appropriate concept, for example the combined-mean formula for item 3 and the grouped-median formula for item 4, while moderate- and low-ability students frequently committed transformation errors, such as confusing the procedure for finding the class midpoint with that for

finding the median, indicating that these students relied more on memorised procedures than on a genuine conceptual understanding of statistics.

In the execution stage, high-ability students carried out the computational algorithm in a coherent sequence. Moderate-ability students had generally selected the correct formula, yet still committed process-skill errors in basic arithmetic operations, such as miscalculating cumulative frequencies or dividing by an incorrect total, whereas low-ability students were unable to initiate the calculation process at all. The weakest stage across all ability levels was checking and concluding: almost no subject, regardless of category, engaged in the reflective "looking back" step emphasised by Polya (1973). High-ability students often obtained the correct numerical answer but neglected to write a final conclusion or the appropriate unit (an encoding error), while moderate- and low-ability students did not check their answers at all, indicating that metacognitive habits remain underdeveloped across the class.

A clear decline in performance was also observed as the cognitive level of the items increased. Students performed comparatively well on items demanding routine analysis and computation of the grouped mean (Bloom's C4 level), reflecting familiarity with the mechanical procedure of computing a weighted mean. Performance dropped sharply, however, on items requiring synthesis and evaluation (C5–C6), namely combining two data groups into a single new mathematical model and evaluating the median class position using cumulative frequency and the lower class boundary rather than the class limit alone. This pattern suggests that students experienced cognitive fatigue and became stuck mid-solution when confronted with non-routine tasks requiring concept transfer, consistent with a classroom culture oriented more towards Lower Order Thinking Skills (LOTS) than towards the flexible reasoning demanded by HOTS items.

These findings corroborate Dewi, Khodijah and Zanthy (2020), who reported that students' greatest difficulty in statistics lies in determining mean values and analysing data, stemming from weak conceptual understanding and an inability to model problems mathematically. The findings are also consistent with Simamora and Tilaar (2021), who found that students' mathematical literacy on HOTS-type items remains limited, particularly in the aspects of analysis and communication; students in the present study were likewise able to compute but struggled to communicate and represent data mathematically, which are defining features of higher-order thinking. Taken together, the results indicate that the mathematical thinking profile of students at SMP Negeri 1 Sukadana in solving HOTS problems on statistics is generally still at an operational-procedural stage rather than an analytical-reflective one. Students can follow an algorithm when the problem format is familiar, but encounter obstacles when a HOTS item demands contextual interpretation, synthesis of concepts, or evaluation of data. Their thinking profile is dominated by drill-based habits, so that when faced with unfamiliar reasoning demands they are unable to adapt their strategy, and the near-universal

absence of a checking and reflection stage shows that students have not yet positioned themselves as active evaluators of the statistical conclusions they produce

Conclusions and Suggestions

The mathematical thinking profile of students at SMP Negeri 1 Sukadana in solving Higher Order Thinking Skills (HOTS) problems on statistics differs systematically across ability levels and follows a consistent pattern along the stages of understanding the problem, planning a strategy, executing the solution, and checking the result. High-ability students can understand the problem, select the correct concept, and work systematically, though they still tend to skip the final checking step; moderate-ability students grasp the problem and often choose the right concept but are hindered by procedural and computational errors; and low-ability students struggle from the outset to comprehend what is asked, select a relevant concept, or carry out the calculation. Across all categories, the near-total absence of reflective checking is the most consistent weakness, indicating that students' mathematical thinking has not yet moved from an operational-procedural level to an analytical-reflective one. This finding underlines the need for teachers to provide more contextual, story-based practice, to habituate students to writing systematic solution steps, and to require answer-checking as a routine part of problem-solving, so that students' higher-order mathematical thinking in statistics can develop beyond mechanical computation.

Bibliography

Aritonang, K.T., 2017. *Profil kemampuan siswa dalam pembelajaran*. Jakarta: Raja Grafindo Persada.

Betha, N., Putrawangsa, S. and Masriyah, 2018. Pengembangan soal Higher Order Thinking Skills (HOTS) dalam pembelajaran matematika. *Jurnal Pendidikan Matematika*, 12(2), pp.120–130.

Dewi, D.K., Khodijah, S.S. and Zanthy, L.S., 2020. Analisis kesulitan matematik siswa SMP pada materi statistika. *Jurnal Cendekia: Jurnal Pendidikan Matematika*, 4(1), pp.1–7.

George, 2021. Metode ilmiah statistika dalam penelitian sosial. *Jurnal Statistika dan Pendidikan*.

Haki, M.A. and Prahastiwi, D.M., 2024. Penyajian data naratif dalam penelitian kualitatif pendidikan. *Jurnal Pendidikan dan Konseling*, 6(1), pp.112–120.

Harahap, N., 2020. *Penelitian kualitatif: Studi kasus fenomena sosial*. Medan: Wal Ashri Publishing.

Hodiyanto, 2017. Kemampuan komunikasi matematis dalam pembelajaran matematika. *Adscribtis: Jurnal Pendidikan Matematika*, 1(1), pp.9–18.

Isnaini, N., 2013. *Komunikasi dan pembelajaran*. Malang: UIN Maliki Malang Press.

Kemendikbud, 2017. *Panduan penulisan soal Higher Order Thinking Skills (HOTS)*. Jakarta: Kementerian Pendidikan dan Kebudayaan.

Kristanto, A., 2019. *Pengembangan media pembelajaran*. Surabaya: Bintang Surabaya.

Kusaeri, 2017. *Penilaian hasil belajar siswa di sekolah*. Yogyakarta: Pustaka Pelajar.

Kusuma Dewi, et al., 2020. Deskripsi kemampuan kognitif siswa dalam konsep matematika. *Jurnal Pendidikan Matematika*.

Land, T., Zulfiani and Zubaidah, S., 2019. Mathematical thinking in mathematics learning. *Journal of Mathematics Education*, 10(1), pp.45–56.

Layyina, H., 2018. Analisis kemampuan berpikir matematis siswa dalam menyelesaikan masalah matematika. *Jurnal Pendidikan Matematika*, 6(2), pp.150–160

Lestari, K.E. and Yudhanegara, M.R., 2015. *Penelitian pendidikan matematika*. Bandung: Refika Aditama.

Maleong, L.J., 2018. *Metodologi penelitian kualitatif*. Bandung: Remaja Rosdakarya.

Miatun, S. and Nurafni, A., 2019. Profil berpikir matematis siswa dalam menyelesaikan masalah matematika. *Jurnal Pendidikan Matematika*, 8(1), pp.22–35.

Montgomery, D.C. and Runger, G.C., 2020. *Applied statistics and probability for engineers*. 7th ed. Hoboken: Wiley.

Newman, M.A., 1977. *An analysis of sixth-grade pupils' performance on a selected group of mathematical problems*. Armidale: University of New England.

Nisa and Susanti, 2019. Penerapan ilmu statistika dalam dunia industri dan pemasaran. *Jurnal Statistika dan Aplikasi*.

Polya, G., 1973. *How to solve it: A new aspect of mathematical method*. Princeton: Princeton University Press.

Pratiwi, 2017. Triangulasi data dalam penelitian kualitatif. *Jurnal Metodologi Penelitian*.

Rahmawati, Y., 2019. Profil kemampuan siswa dalam pembelajaran matematika. *Jurnal Pendidikan dan Pembelajaran*, 8(2), pp.90–98.

Rijali, A., 2018. Analisis data kualitatif. *Alhadharah: Jurnal Ilmu Dakwah*, 17(33), pp.81–95.

Sabirova, F.M., Gilmanov, L.I. and Safin, R.R., 2020. Development of students' mathematical thinking in learning mathematics. *International Journal of Instruction*, 13(1), pp.1–12.

Sani, R.A., 2019. *Pembelajaran berbasis HOTS (Higher Order Thinking Skills)*. Jakarta: Bumi Aksara.

Simamora, K.A.L.G. and Tilaar, A.L.F., 2021. Analisis kemampuan literasi matematika siswa pada soal tipe HOTS. *Jurnal Pendidikan Matematika*, 9(2), pp.150–165.

Sugiyono, 2016. *Metode penelitian kualitatif*. Bandung: Alfabeta.

Sugiyono, 2018. *Metode penelitian pendidikan: Pendekatan kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta.

Suyitno, A., Amin, S.M. and Suyitno, I., 2018. Pengembangan soal matematika berbasis HOTS untuk meningkatkan literasi matematis siswa. *Jurnal Pendidikan Matematika*, 12(1), pp.1–12.

Tim Penyusun Kamus Pusat Bahasa, 2017. *Kamus Besar Bahasa Indonesia*. 5th ed. Jakarta: Balai Pustaka.

Witte, R.S. and Witte, J.S., 2020. *Statistics*. 11th ed. Hoboken: Wiley.