Jurnal Didaktika Pendidikan Dasar

doi: https://doi.org/10.26811/didaktika.v9i3.2005

E-ISSN: 2746-0525
P-ISSN: 2580-006X

Vol. 9, No. 3, November 2025

Page: 1015-1036

MAPPING FIFTH-GRADE STUDENTS CONCEPTUAL UNDERSTANDING OF CUBE POWERS AND CUBE ROOTS: A DESCRIPTIVE STUDY AT SD NEGERI 2 KENDARI

Muhammad Ilham[1]; Imaludin Agus[2]; Hasnia[3]; Asep Saeful Rohman[4]
[1,2,3]Institut Agama Islam Negeri Kendari, Sulawesi Tenggara, Indonesia
[4]Universitas Padjajaran, Jawa Barat, Indonesia
[1]Contributor Email: muhammadilham@iainkendari.ac.id

Received: August 1, 2025 **Accepted:** October 21, 2025 **Published:** November 30, 2025
Article Url: https://ojsdikdas.dikdasmen.go.id/index.php/didaktika/article/view/2005

Abstract

This study aims to map the conceptual understanding of fifth-grade students at SD Negeri 2 Kendari regarding cube powers and cube roots. Using a qualitative descriptive approach, the research investigates three indicators of conceptual understanding: classification of mathematical objects, selection and use of procedures, and application of concepts in problem-solving. Data were collected through a written conceptual-understanding test and follow-up interviews with students representing high-, medium-, and low-performance groups. The findings show that students' conceptual understanding is uneven across indicators. Most students demonstrated adequate ability to classify cubic numbers and identify structural characteristics of cube powers. However, substantial difficulties emerged in selecting appropriate procedures and understanding the multiplicative structure underlying cube powers and their inverse operations. Misconceptions, such as interpreting cubing as repeated addition or treating cube roots as simple division—were evident among medium- and especially low-performing students. Problem-solving posed the greatest challenge, with many students struggling to integrate information, select relevant operations, or apply concepts in contextual situations. Overall, the study provides a detailed profile of students' conceptual strengths and challenges, offering insights that can inform instructional improvement. The results highlight the need for learning experiences that emphasize conceptual relationships, multiple representations, and explicit correction of misconceptions to support deeper mathematical understanding.

Keywords: *Conceptual Understanding; Elementary Mathematics; Cube Powers; Cube Roots; Misconceptions; Problem-Solving.*

E-ISSN: 2746-0525/ P-ISSN: 2580-006X doi: 10.26811/didaktika.v9i3.2005

Abstrak

Penelitian ini bertujuan untuk memetakan pemahaman konseptual siswa kelas V di SD Negeri 2 Kendari terkait pangkat tiga (kubik) dan akar pangkat tiga. Dengan menggunakan pendekatan deskriptif kualitatif, penelitian ini mengkaji tiga indikator pemahaman konseptual: klasifikasi objek matematika, pemilihan dan penggunaan prosedur, serta penerapan konsep dalam pemecahan masalah. Data dikumpulkan melalui tes tertulis pemahaman konseptual dan wawancara lanjutan dengan siswa yang mewakili kelompok berkemampuan tinggi, sedang, dan rendah. Hasil penelitian menunjukkan bahwa pemahaman konseptual siswa tidak merata pada setiap indikator. Sebagian besar siswa menunjukkan kemampuan yang cukup dalam mengklasifikasikan bilangan kubik dan mengidentifikasi karakteristik struktural pangkat tiga. Namun, muncul kesulitan yang cukup besar dalam memilih prosedur yang tepat dan memahami struktur multiplikatif yang mendasari operasi pangkat tiga serta operasi inversnya. Miskonsepsi, seperti mengartikan pemangkatan tiga sebagai penjumlahan berulang atau menganggap akar pangkat tiga sebagai pembagian sederhana – tampak pada siswa berkemampuan sedang dan terutama rendah. Pemecahan masalah menjadi tantangan paling besar, di mana banyak siswa kesulitan mengintegrasikan informasi, memilih operasi yang relevan, atau menerapkan konsep dalam situasi kontekstual. Secara keseluruhan, penelitian ini memberikan profil terperinci mengenai kekuatan dan tantangan pemahaman konseptual siswa, sekaligus menawarkan wawasan yang dapat digunakan untuk perbaikan pembelajaran. Hasil ini menegaskan perlunya pengalaman belajar yang menekankan hubungan antarkonsep, representasi yang beragam, serta koreksi eksplisit terhadap miskonsepsi untuk mendukung pemahaman matematika yang lebih mendalam.

Kata Kunci: *Pemahaman Konseptual; Matematika Sekolah Dasar; Pangkat Tiga; Akar Pangkat Tiga; Miskonsepsi; Pemecahan Masalah.*

A. Introduction

Mathematics education serves as a cornerstone for fostering students cognitive development, particularly in cultivating logical reasoning, critical thinking, and problem-solving abilities. At the primary level, students are introduced to essential mathematical domains, such as number operations, geometry, and early algebra, which provide the structural foundation for future learning. Within these domains, conceptual understanding holds a particularly vital role because it enables students to connect ideas, recognize underlying principles, and meaningfully apply mathematical knowledge across various contexts. International assessments such as the Trends in International Mathematics and Science Study (TIMSS) have consistently documented Indonesian students' difficulties with conceptual tasks that demand more than procedural recall (Mohamed et al., 2021; Putra et al., 2024). While such findings provide an important national backdrop, the specific nature and manifestation of conceptual challenges can differ significantly across local school settings, instructional practices, and students' prior learning experiences.

In the context of SD Negeri 2 Kendari, preliminary assessments and classroom observations conducted prior to this study revealed recurring conceptual challenges related to the topic of cube powers and cube roots among fifth-grade students. This topic is conceptually demanding for upper elementary learners because it requires them to integrate multiplicative reasoning, spatial visualization of three-dimensional structures, and symbolic interpretation of exponential notation. Teacher reports and diagnostic test results indicated that students frequently confuse squaring with cubing, misinterpret cube roots as simple division, and demonstrate difficulty articulating the inverse relationship between cubing and cube roots. These issues suggest that while students may have been introduced to relevant procedures, they have not yet developed sufficiently robust conceptual frameworks to support meaningful understanding.

The persistence of these misconceptions reflects broader instructional trends in mathematics education. Although the Indonesian curriculum outlines a balanced emphasis on conceptual depth and procedural fluency, classroom practices often remain heavily oriented toward algorithmic instruction (Copur-Gencturk, 2021). As a result, students may learn to perform steps mechanically without understanding why those steps work, an issue well documented in studies examining procedural versus conceptual knowledge (Banawi et al., 2022; Prosser & Bismarck, 2023). Research shows that conceptual understanding is essential for long-term retention, flexible problem-solving, and transfer to unfamiliar contexts, while procedural-only learning tends to result in surface-level mastery that diminishes over time (Young & Shtulman, 2020; Souza & Powell, 2021).

Moreover, several contextual factors may exacerbate conceptual challenges in elementary mathematics. These include limitations in

E-ISSN: 2746-0525/ P-ISSN: 2580-006X doi: 10.26811/didaktika.v9i3.2005

teacher access to high-quality professional development (Fauth et al., 2019), disparities in learning resources across schools (Sartono et al., 2024), and socio-emotional barriers such as math anxiety or low motivation (Yaman, 2023). Linguistic factors also influence students' conceptual development; ambiguous or abstract phrasing in textbooks and instructional materials can hinder students' comprehension of mathematical ideas (Lane et al., 2014). The topic of cube powers and cube roots is particularly susceptible to such linguistic and representational difficulties because it requires students to transition fluidly between concrete, representational, and abstract forms of reasoning.

This concern aligns with existing literature indicating that misconceptions about exponentiation often arise from limited exposure to manipulatives, insufficient opportunities to explore three-dimensional representations, and a lack of structured support for understanding the multiplicative structure of exponents (Mahmood, 2014; Shahid et al., 2023). For example, students who do not engage with physical or visual models of cubes may struggle to internalize why cubing involves repeated multiplication rather than repeated addition. Similarly, students who have not encountered inverse operations in meaningful contexts may have difficulty conceptualizing cube roots beyond procedural shortcuts.

Despite a growing body of research on strategies that support conceptual learning, including inquiry-based learning (Macanas & Rogayan, 2019; Walker et al., 2022), the Concrete–Representational–Abstract (CRA) progression (Prosser & Bismarck, 2023), and hands-on learning stations (Bulunuz & Jarrett, 2010), empirical studies examining how elementary students understand cube powers and cube roots remain scarce. Most existing research focuses on secondary students or on broader domains such as number sense or fractional reasoning. Consequently, there is a lack of detailed, context-specific evidence on how conceptual understanding of cube powers and cube roots develops among younger learners, particularly within Indonesian public school settings.

Addressing this gap requires a focused examination of students' conceptual profiles in relation to specific indicators. Mutawah et al. (2019) propose three dimensions of conceptual understanding that are especially relevant for this study: (1) the ability to classify mathematical objects based on their defining characteristics, (2) the ability to select and use appropriate procedures or operations, and (3) the ability to apply concepts in solving problems, including those in real-world contexts. Understanding how students perform across these indicators can provide valuable insights into the types of support they need and the nature of misconceptions they hold.

To this end, the present study aims to map the conceptual understanding of fifth-grade students at SD Negeri 2 Kendari with respect to cube powers and cube roots. Through diagnostic test items and semi-structured interviews, this research seeks to uncover patterns of reasoning, common errors, and areas of conceptual strength and weakness among students at different performance levels. By employing a qualitative descriptive approach, the study provides nuanced insights that complement existing quantitative findings on student performance in mathematics. The results are intended to inform the design of instructional strategies and intervention programs that more effectively promote conceptual learning in the elementary classroom.

B. Method

1. Research Design

This study employed a qualitative descriptive design to investigate fifth-grade students conceptual understanding of cube powers and cube roots at SD Negeri 2 Kendari. A qualitative descriptive approach is appropriate when the goal is to provide a detailed, straightforward account of participants' learning processes, misconceptions, and reasoning patterns without imposing interpretive theoretical frameworks (Fauth et al., 2019). In mathematics education research, this design allows researchers to examine students' thinking as it appears in authentic learning environments and to describe their conceptual profiles based on empirical evidence drawn from both written and verbal data (Copur-Gencturk, 2021). In this study, the approach was used to analyze how students classified mathematical objects, selected procedures, and engaged in problem-solving related to cube powers and cube roots.

E-ISSN: 2746-0525/ P-ISSN: 2580-006X doi: 10.26811/didaktika.v9i3.2005

2. Participants and Sampling

The participants were 36 fifth-grade students enrolled at SD Negeri 2 Kendari during the 2022/2023 academic year. From this group, six students were purposively selected for interviews to represent varying levels of conceptual understanding: high, medium, and low. Classification into these categories was based on students' scores on a conceptual understanding test. Students scoring above 75 were categorized as high-performing, those scoring between 60 and 74.9 as medium-performing, and those scoring below 60 as low-performing. Purposive sampling was used to ensure that the selected students could provide rich and diverse insights into the range of conceptual challenges and reasoning patterns observed in the class, consistent with Creswell and Poth's (2018) recommendation for obtaining information-rich cases in qualitative inquiry.

3. Data Collection Instruments

Two forms of data were collected: (1) written test responses and (2) semi-structured interviews. The written test consisted of five essay-type items focusing on cube powers and cube roots, constructed based on indicators of conceptual understanding proposed by Mutawah et al. (2019). These indicators include the ability to classify mathematical objects, select and use appropriate procedures, and apply concepts in solving problems. The items underwent expert validation, including face validation and Aiken's V analysis, resulting in coefficients ranging from 0.85 to 0.97, indicating high validity. Reliability testing using Cronbach's Alpha produced a coefficient of 0.512, representing moderate internal consistency and confirming the suitability of the instrument for elementary-level conceptual assessment (Sugiyono, 2018).

Semi-structured interviews were conducted with the six purposively selected students to further investigate reasoning processes and clarify written responses. The interview protocol was aligned with the same conceptual indicators used in the written test. This dual-format data collection - written and verbal - allowed triangulation of student responses and provided a more comprehensive account of their conceptual understanding, consistent with Levy and Mensah (2020), who emphasized the value of interviews in revealing cognitive processes not fully captured in written assessments.

4. Data Analysis Procedures

Data were analyzed using the Miles and Huberman (1984) qualitative analysis model, which consists of three interconnected phases: data reduction, data display, and conclusion drawing/verification. In the data reduction phase, students' written and interview responses were transcribed, organized, and coded according to the three conceptual indicators. Only relevant excerpts that revealed understanding, partial understanding, or misconceptions were retained for further analysis. In the data display phase, responses were arranged into matrices and descriptive summaries to compare patterns across high-, medium-, and low-performing groups. This structured visual organization enabled clear identification of differences in conceptual understanding and highlighted recurring misunderstandings related to cube powers and cube roots.

In the final phase, conclusions were drawn by identifying themes emerging from the patterns in the data and verifying them through triangulation between test results and interview findings. This systematic, iterative analysis ensured that interpretations were grounded in evidence and reflected students' authentic reasoning processes. In addition, scoring rubrics aligned with the conceptual indicators were used to support analytical consistency and to validate interpretations of students' conceptual performance.

5. Instrument Indicators and Validation Procedures

The conceptual indicators guiding both data collection and analysis were: (1) the ability to classify mathematical objects based on shared characteristics, (2) the ability to use and select appropriate procedures, and (3) the ability to apply concepts in problem-solving contexts. Each indicator was operationalized through specific written test items as well as interview prompts. The expert validation process ensured that each item appropriately reflected the intended indicator. The interviews were also piloted with 32 students to refine question phrasing and clarity, ensuring that prompts were accessible and understandable for

E-ISSN: 2746-0525/ P-ISSN: 2580-006X doi: 10.26811/didaktika.v9i3.2005

fifth-grade learners. These validation procedures contributed to the overall trustworthiness of the research instruments.

C. Results and Discussion

1. Result

a. Overall Performance Distribution

The results of the conceptual-understanding test administered to 36 fifth-grade students at SD Negeri 2 Kendari show substantial variation in students' mastery of cube powers and cube roots. Although more than half of the students demonstrated relatively strong performance, the overall distribution reveals notable differences in how students internalize and apply these concepts.

Table 1. Distribution of Fifth-Grade Students' Conceptual Understanding of Cube Powers and Cube Roots

Performance Category	Number of Students (n)	Percentage	Mean Score	Brief Interpretation
High	19	52.8 %	84.0	Strong mastery of cube powers and cube roots.
Medium	15	41.7 %	69.0	Partial understanding; procedural and application skills need reinforcement.
Low	2	5.5 %	43.4	Fundamental difficulties with exponents and root operations
Total	36	100%		

As shown in Table 1, 19 students achieved scores categorized as high, indicating that these students generally possessed adequate conceptual grounding and were able to integrate multiple elements of the topic, such as recognizing cubic relationships and identifying cube roots, into coherent reasoning. Meanwhile, 15 students fell into the medium category. Their responses typically reflected partial understanding; they could identify basic relationships but frequently made errors when the tasks required multi-step reasoning or conceptual transfer. Only two students were classified as low-performing. Their work revealed fragmented understanding and misconceptions that interfered with both simple and complex tasks.

This distribution suggests that conceptual understanding is uneven across the class. While a substantial number of students can perform basic tasks related to cube powers and roots, deeper reasoning remains a challenge for many. The presence of only two low-performing students might indicate that most students possess at least foundational procedural knowledge. However, several responses showed that even medium-performing students struggled to articulate relationships or justify answers, reflecting that conceptual depth is not yet consistently achieved.

Table 2. Descriptive Statistics for Conceptual-Understanding Test Scores (n = 36)

Statistic	Value
Mean	75.0
Median	80.0
Mode	80.0
Standard Deviation	13.08
Sample Variance	171.18
Range	66.7
Minimum	33.3
Maximum	100.0
Sum	2735.6
Sample Size (n)	36

Complementing these findings, Table 2 presents descriptive statistics for the test results. Although the mean (75.0) and median (80.0) suggest that overall performance leans toward the medium-to-high range, the relatively large standard deviation (13.08) and wide score range indicate that students' conceptual profiles vary considerably. This heterogeneity aligns with interview findings showing differences in students' ability to explain reasoning and connect procedures with underlying concepts.

Taken together, these results illustrate that the class includes students with strong conceptual grounding while simultaneously highlighting persistent gaps, particularly among medium and low

E-ISSN: 2746-0525/ P-ISSN: 2580-006X doi: 10.26811/didaktika.v9i3.2005

performing students who struggle to interpret exponentiation beyond procedural steps.

b. Indicator-Based Performance

To better understand specific areas of conceptual strength and weakness, students' responses were analyzed according to three indicators: classification, procedure selection, and problem-solving. The analysis reveals clear patterns in how students approached the tasks related to cube powers and cube roots.

Table 3. Student Achievement by Conceptual Understanding Indicators

Conceptual Indicator	Score Achieved	Percentage (%)	Interpretation
Classification	44	45	Strongest performance; students can group and identify cube-related mathematical objects effectively
Procedure Selection	30	31	Moderate performance; students can choose appropriate methods but often make execution errors
Problem-Solving	23	23	Weakest performance; students struggle to apply concepts to new or real-world problems

As shown in Table 3, students performed best on the classification indicator (45%). Many were able to identify characteristics of cubic numbers and distinguish cube-related objects from non-cubic ones. Their written work often showed correct recognition of cube number sequences or appropriate comparisons of cubic volumes. This suggests that students are generally comfortable with tasks requiring recognition or categorization, especially when numerical or structural patterns are explicit.

Performance decreased considerably in the procedure selection indicator (31%). Although some students correctly identified that cube roots are inverse operations of cubing, their execution often revealed incomplete understanding. Medium-performing students tended to choose appropriate strategies but made errors in computation or failed to justify procedural steps. Low-performing students frequently misinterpreted cube root tasks, with several responses suggesting confusion between cube roots and simple division or subtraction. These findings illustrate that while students may recall procedures, their conceptual clarity about why or how procedures work remains limited.

The problem-solving indicator (23%) was the most challenging. Only a minority of students were able to apply concepts to contextual scenarios or multi-step problems. Even students who performed strongly in classification faced difficulty when asked to integrate conceptual understanding with procedural decisions in applied contexts. This finding supports earlier observations that students' reasoning tends to be compartmentalized, they can recognize concepts in isolation but struggle when they must interpret, transform, and apply them simultaneously.

Overall, the indicator-based analysis demonstrates that students' strengths lie primarily in recognition and categorization tasks, while sustained reasoning, application, and justification remain areas requiring instructional support.

c. Interview Findings

The interview data provide deeper insight into students' reasoning processes and conceptual understanding of cube powers and cube roots. Consistent with the three indicators used in this study, classification, procedure selection, and problem-solving, distinct patterns emerged across high-, medium-, and low-performing students. These findings reinforce the patterns identified in the written test and help illuminate students' conceptual strengths and difficulties.

1) Classification of Objects

In the classification indicator, high-performing students demonstrated the strongest conceptual clarity. When asked to identify a cubic number between 200 and 300, one high-performing student explained that they first "looked for a number whose cube lies within that interval." The student then identified $63^3 = 216$ as the correct value. This

Vol. 9, No. 3, November 2025
E-ISSN: 2746-0525/ P-ISSN: 2580-006X
doi: 10.26811/didaktika.v9i3.2005

explanation reflects not only procedural knowledge but also a clear understanding of the structure of cube powers—an understanding further illustrated in *Figure 1*, which shows the student's organized and accurate computation.

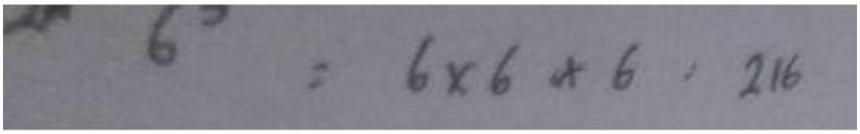

Figure 1. Example of a high-performing student's work on identifying a cubic number.

Medium-performing students generally understood the process of categorizing or ordering cubic quantities but often made calculation errors when dealing with larger numbers. In the interview, one student described their process ("first calculate each cube's volume, then order them"), but inaccuracies in their final results suggested that the conceptual process was in place while computational fluency remained unstable.

Low-performing students, on the other hand, showed substantial difficulty articulating what makes a number cubic. Many provided answers without clear justification or relied on guessing. Their verbal explanations indicated that the foundational idea of "multiplying a number by itself three times" was not yet internalized. This aligns with their written work, which lacked evidence of structured reasoning.

Taken together, these findings show that students' ability to classify cubic objects is strongly tied to the stability of their understanding of the cube operation itself, with clearer distinctions in reasoning and accuracy appearing across performance groups.

2) Selection and Use of Procedures

Differences in procedural understanding were even more apparent when students were asked to determine cube roots. High-performing students articulated that cube roots represent the inverse operation of cube powers and described searching for the base number that, when cubed, yields the target value. Their responses reflected awareness of the structural relationship between an operation and its inverse.

In contrast, low-performing students exhibited fundamental conceptual misunderstandings. One student, when asked how to determine √2744, stated that they solved it by "adding 2,744 three times." This response reveals a misconception in which cube powers are incorrectly treated as repeated addition rather than repeated multiplication. This procedural confusion is clearly seen in *Figure 2*, which depicts the student's incorrect repeated-addition strategy.

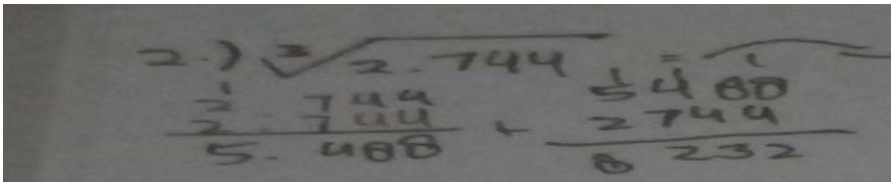

Figure 2. Example of a low-performing student's work showing an incorrect approach to solving a cube root problem.

Medium-performing students showed partial understanding. They often selected the correct strategy (i.e., identifying cube roots as inverse cube operations) but struggled with accuracy, particularly with larger numerical values. Their explanations suggest that procedural knowledge existed, but conceptual justification was incomplete, leaving gaps in the execution of correct procedures.

These interview findings show that students' selection and use of procedures are highly dependent on their internalization of the multiplicative nature of cube powers. Misunderstandings in this structural concept lead directly to errors in determining cube roots.

3) Application of Concepts in Problem-Solving

The application indicator presented the greatest challenge for most students. High-performing students demonstrated a systematic and coordinated approach when solving contextual problems such as determining the volume of an aquarium or calculating the amount of water needed to fill it. During interviews, they described beginning by identifying the known quantities, performing the necessary multiplications, and then converting the results into the required units. Their written solutions, as

Vol. 9, No. 3, November 2025
E-ISSN: 2746-0525/ P-ISSN: 2580-006X
doi: 10.26811/didaktika.v9i3.2005

illustrated in *Figure 3*, show clear procedural sequencing and accurate decision-making in unit conversion.

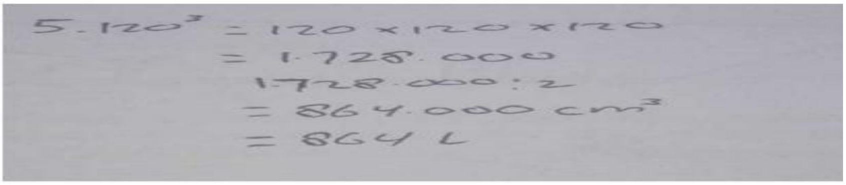

Figure 3. Example of a high-performing student's work on calculating water volume in liters.

Medium-performing students typically understood the context of the problem and selected relevant operations but made numerical errors during computation. For example, one student recognized the need to multiply length, width, and height but arrived at an incorrect final volume. This type of error, depicted in *Figure 4*, indicates that while the conceptual framework for problem-solving exists, precision in execution remains a challenge.

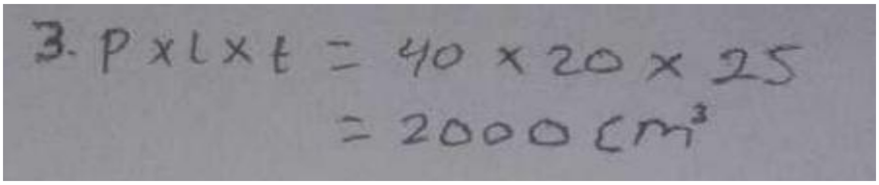

Figure 4. Example of a medium-performing student's work with miscalculated aquarium volume.

Low-performing students encountered difficulties from the earliest steps of the problem-solving process. Many struggled to identify essential information in the problem statement and could not translate dimensional descriptions into appropriate operations. Their interviews revealed that the connection between multiplication of dimensions and the concept of three-dimensional volume was not well established. As a result, they were unable to appropriately apply mathematical concepts in real-world contexts.

d. Synthesis of Interview Findings

Across all indicators, the interview data confirm that: (a) Classification is the strongest area for most students, especially those in the high and medium groups; (b) Procedure selection clearly differentiates students with stable conceptual structures from those who rely on memorized or incorrect routines; (3) Problem-solving highlights the deepest conceptual gaps, requiring students not only to recall concepts but to integrate and apply them across representational forms and contexts.

Overall, the interviews show that many students possess fragments of conceptual understanding but struggle to integrate these elements into coherent reasoning, particularly in tasks requiring justification or contextual application. These findings underscore the importance of instructional approaches that strengthen conceptual connections, support reasoning across representations, and address misconceptions through targeted scaffolding.

2. Discussion

The findings of this study reveal distinct patterns in fifth-grade students' conceptual understanding of cube powers and cube roots, providing a nuanced description of how students at different performance levels interpret, reason with, and apply these mathematical concepts. The qualitative descriptive approach enables the identification of these patterns without imposing theoretical assumptions beyond what the data reveal, while allowing the findings to be meaningfully connected to existing research in mathematics education.

a. Conceptual Understanding Across Indicators

Overall, students demonstrated stronger performance in tasks involving classification compared to procedure selection and problem-solving. This pattern suggests that students are more comfortable

E-ISSN: 2746-0525/ P-ISSN: 2580-006X
doi: 10.26811/didaktika.v9i3.2005

recognizing or categorizing mathematical ideas when cues are explicit. Such findings align with Mutawah et al. (2019), who argue that classification tasks rely more on recognition of surface features than on deep structural understanding. In the present study, high- and medium-performing students were generally able to identify cubic numbers or compare cubic volumes, indicating that they had acquired some foundational understanding of the structure of cube powers.

However, as tasks moved toward more complex indicators—particularly procedure selection and contextual problem-solving—students' reasoning tended to become less consistent and more fragmented. This progression from stronger recognition to weaker application reflects the differentiation between conceptual and procedural knowledge described by Banawi et al. (2022) and Prosser and Bismarck (2023). Students may recall or recognize ideas but still struggle to integrate them into coherent procedures, especially when the task requires understanding inverse operations or coordinating multiple steps.

b. Misconceptions and Their Cognitive Origins

The interviews, combined with the written responses, reveal several recurring misconceptions. The most prominent include: (1) Interpreting cubing as repeated addition rather than repeated multiplication; (2) Confusing square numbers with cube numbers; (3) Viewing cube roots as division by three; (4) Treating cube-root tasks as routine arithmetic rather than inverse operations.

These misconceptions reflect incomplete internalization of the multiplicative structure of exponents, a difficulty widely reported in studies involving exponentiation at elementary and middle-school levels (Mahmood, 2014; Young & Shtulman, 2020). Students who rely on memorized rules are more likely to misapply procedures when presented with unfamiliar formats or contexts, as seen in several medium- and low-performing students in this study.

Limited exposure to concrete and representational experiences may also contribute to these misunderstandings. Research on instructional models such as the Concrete–Representational–Abstract (CRA) framework emphasizes the importance of moving students from physical manipulation to symbolic reasoning (Prosser & Bismarck, 2023). The lack of such experiences may explain why some students struggled to visualize or conceptualize the three-dimensional nature of cube powers and the inverse logic of cube roots.

c. Problem-Solving as the Most Challenging Indicator

Problem-solving emerged as the area where conceptual gaps were most visible. Even students who demonstrated strong classification abilities often struggled with multi-step contextual tasks such as determining the volume of containers or converting units. These findings emphasize that problem-solving requires students to integrate classification, procedural selection, and reasoning simultaneously—abilities that are not yet fully developed in many elementary learners.

This aligns with Arieli-Attali and Cayton-Hodges (2014), who state that conceptual understanding becomes evident when students can transfer knowledge across contexts and representational forms. In the present study, students who lacked this integrated understanding tended to: misidentify relevant information, select inappropriate procedures, or perform calculations without understanding their purpose.

These patterns suggest that conceptual understanding remains compartmentalized for many students, meaning that ideas learned in isolation (e.g., cube recognition) are not yet connected to applied reasoning.

d. Implications for Instruction and Learning

The findings point to several instructional needs. First, students would benefit from learning experiences that emphasize conceptual relationships rather than procedural memorization. Consistent with recommendations from Souza and Powell (2021), textbook and classroom

E-ISSN: 2746-0525/ P-ISSN: 2580-006X
doi: 10.26811/didaktika.v9i3.2005

tasks should integrate multiple representations—numeric, symbolic, visual, and contextual—to strengthen students' conceptual networks.

Second, students require structured opportunities for reasoning, including open-ended tasks, reflective questioning, and guided inquiry. Approaches such as inquiry-based learning (Macanas & Rogayan, 2019) and hands-on exploration (Bulunuz & Jarrett, 2010) may support students in constructing meaning and resolving inconsistencies in their thinking.

Third, explicit attention should be given to misconception correction**.** For example, contrasting correct and incorrect examples—as suggested by Young & Shtulman (2020)—could help destabilize misconceptions such as equating cubing with tripling or misinterpreting cube roots.

Finally, teachers need support in diagnosing and addressing conceptual difficulties. The findings of this study align with Copur-Gencturk (2021) and Fauth et al. (2019), who emphasize that teacher expertise plays a critical role in fostering conceptual learning. Professional development that focuses on conceptual teaching strategies and formative assessment could strengthen teachers' capacity to respond to such challenges.

e. Contribution and Limitations

This study contributes to the limited body of research on elementary students' conceptual understanding of cube powers and cube roots, particularly within the Indonesian context. By mapping students' understanding across multiple indicators and triangulating written and interview data, the study offers a rich description of conceptual strengths and difficulties that can inform instructional improvement.

However, as a descriptive study conducted in a single school, the findings are not intended for broad generalization. Instead, they provide context-specific insights that can serve as a basis for further research, including intervention studies or longitudinal investigations of conceptual development.

D. Conclusion

This study set out to map the conceptual understanding of fifth-grade students at SD Negeri 2 Kendari in the domain of cube powers and cube roots, focusing on three key indicators: classification, procedure selection, and problem-solving. The findings demonstrate that conceptual understanding in this topic is uneven across students, with clear distinctions between high, medium, and low-performing groups. While many students were able to recognize and classify cubic numbers and related structures, fewer were able to select and apply appropriate procedures, and even fewer successfully transferred these concepts to contextual problem-solving tasks.

The analysis of written responses and interviews revealed that most students possess partial or surface-level understanding, particularly regarding the multiplicative structure of cube powers and the inverse relationship inherent in cube roots. Misconceptions—such as interpreting cubing as repeated addition or viewing cube roots as simple division—emerged as key barriers to deeper understanding. These findings highlight the importance of supporting students in moving beyond procedural recall toward more relational and integrated conceptual frameworks.

Problem-solving presented the greatest challenge for many students, indicating that conceptual knowledge remains compartmentalized rather than fully connected across representations and contexts. High-performing students demonstrated the ability to integrate conceptual and procedural knowledge effectively, but medium- and low-performing students frequently struggled to coordinate information, select appropriate operations, or justify their reasoning. This pattern underscores the need for instructional practices that emphasize reasoning, conceptual coherence, and opportunities to construct meaning through multiple representations and contextualized tasks.

Overall, the study contributes a detailed and context-specific portrait of elementary students' conceptual understanding of cube powers and cube roots an area that has received limited attention in prior research. The findings provide valuable insight for teachers and curriculum designers seeking to strengthen conceptual learning in mathematics. Instructional

E-ISSN: 2746-0525/ P-ISSN: 2580-006X
doi: 10.26811/didaktika.v9i3.2005

interventions that incorporate concrete experiences, representational transitions, guided inquiry, and explicit misconception correction may support students in developing more robust conceptual understanding. While the results reflect the experiences of students in a single school, they offer a foundation for future research and for designing targeted instructional supports that can be adapted to similar educational contexts.

Daftar Referensi

Arieli-Attali, M., & Cayton-Hodges, G. A. (2014). Expanding The<i><scp>CBAL</Scp></I>™ Mathematics Assessments To Elementary Grades: The Development of a Competency Model and a Rational Number Learning Progression. *Ets Research Report Series*, *2014*(1), 1–41. https://doi.org/10.1002/ets2.12008

Banawi, A., Sulaeman, S., Ridwan, M., Sopandi, W., Kadarohman, A., & Solehuddin, M. (2022). Developing Conceptual Change Text on the States of Matter and Their Changes for Prospective Elementary School Teachers. *Pertanika Journal of Social Sciences and Humanities*, *30*(4), 1955–1974. https://doi.org/10.47836/pjssh.30.4.25

Bulunuz, N., & Jarrett, O. S. (2010). The Effects of Hands-on Learning Stations on Building American Elementary Teachers' Understanding About Earth And Space Science Concepts. *Eurasia Journal of Mathematics Science and Technology Education*, *6*(2). https://doi.org/10.12973/ejmste/75230

Copur-Gencturk, Y. (2021). Teachers' Conceptual Understanding of Fraction Operations: Results From a National Sample of Elementary School Teachers. *Educational Studies in Mathematics*, *107*(3), 525–545. https://doi.org/10.1007/s10649-021-10033-4

Creswell, J. W., & Poth, C. N. (2018). *Qualitative Inquiry and Research Design: Choosing Among Five Approaches* (4th ed.). SAGE Publications.

Fauth, B., Decristan, J., Decker, A., Büttner, G., Hardy, I., Klieme, E., & Kunter, M. (2019). The Effects of Teacher Competence on Student Outcomes in Elementary Science Education: The Mediating Role of Teaching Quality. *Teaching and Teacher Education*, *86*, 102882. https://doi.org/10.1016/j.tate.2019.102882

Kotler, R., Rosario, M., Varelas, M., Phillips, N. C., Tsachor, R. P., &

Woodard, R. (2024). Latinx Students Embodying Justice-centered Science: Agency Through Imagining via the Performing Arts. *Science Education*, *108*(3), 851–889. https://doi.org/10.1002/sce.21859

Lane, J. D., Wellman, H. M., & Evans, E. M. (2014). Approaching an Understanding of Omniscience From the Preschool Years to Early Adulthood. *Developmental Psychology*, *50*(10), 2380–2392. https://doi.org/10.1037/a0037715

Levy, A. R., & Mensah, F. M. (2020). Learning Through the Experience of Water in Elementary School Science. *Water*, *13*(1), 43. https://doi.org/10.3390/w13010043

Macanas, G. A., & Rogayan, D. V. (2019). Enhancing Elementary Pupils' Conceptual Understanding on Matter Through Sci-Vestigative Pedagogical Strategy (SPS). *Participatory Educational Research*, *6*(2), 206–220. https://doi.org/10.17275/per.19.22.6.2

Mahmood, A. (2014). Understanding of Elementary School Teachers of 3rd World Country About Levels of SOLO Taxonomy. *Mediterranean Journal of Social Sciences*. https://doi.org/10.5901/mjss.2014.v5n23p1135

Miles, M. B., & Huberman. (1984). *Qualitative data analysis: A Sourcebook of new methods, California*. Sage Publication.

Mohamed, R., Ghazali, M., & Samsudin, M. A. (2021). A Systematic Review on Teaching Fraction for Understanding Through Representation on Web of Science Database Using PRISMA. *Lumat International Journal on Math Science and Technology Education*, *9*(1). https://doi.org/10.31129/lumat.9.1.1449

Mutawah, M. A. Al, Thomas, R., Eid, A., Mahmoud, E. Y., & Fateel, M. J. (2019). Conceptual Understanding, Procedural Knowledge and Problem-Solving Skills in Mathematics: High School Graduates Work Analysis and Standpoints. *International Journal of Education and Practice*, *7*(3), 258–273. https://doi.org/10.18488/journal.61.2019.73.258.273

Prosser, S. K., & Bismarck, S. F. (2023). Concrete–Representational–Abstract (CRA) Instructional Approach in an Algebra I Inclusion Class: Knowledge Retention Versus Students' Perception. *Education Sciences*, *13*(10), 1061. https://doi.org/10.3390/educsci13101061

Putra, L. V, Sukestiyarno, Masrukan, & Widodo, J. (2024). Integrating

E-ISSN: 2746-0525/ P-ISSN: 2580-006X
doi: 10.26811/didaktika.v9i3.2005

Numeration in Mathematics Learning. *Edelweiss Applied Science and Technology*, *8*(4), 1699–1710. https://doi.org/10.55214/25768484.v8i4.1546

Sartono, S., Triswandari, R., Nisa, S., Safitri, S., Ariani, Y., Zainil, M., & Helsa, Y. (2024). Analysis of Students' Learning Loss in Math in Padang City, Indonesia. *Jurnal Pendidikan Matematika*, *18*(3), 431–446. https://doi.org/10.22342/jpm.v18i3.pp431-446

Shahid, S., Kanwal, W., & Parveen, K. (2023). Effectiveness of Science Textbook Activities for Conceptual Understanding of Students. *Journal of Management Practices Humanities and Social Sciences*, *7*(2). https://doi.org/10.33152/jmphss-7.2.1

Souza, M. A. V. F. de, & Powell, A. B. (2021). How Do Textbooks From Brazil, the United States, and Japan Deal With Fractions? *Acta Scientiae*, *23*(4), 77–111. https://doi.org/10.17648/acta.scientiae.6413

Sugiyono. (2018). *Metode penelitian kuantitatif, kualitatif dan R & D*. Alfabeta.

Walker, T. J., Kohl, H. W., Bartholomew, J. B., Green, C., & Fernández, M. E. (2022). Using Implementation Mapping to Develop and Test an Implementation Strategy for Active Learning to Promote Physical Activity in Children: A Feasibility Study Using a Hybrid Type 2 Design. *Implementation Science Communications*, *3*(1). https://doi.org/10.1186/s43058-022-00271-9

Yaman, H. (2023). A Thematic Review of Studies on Specific Learning Disabilities in Science Education. *Participatory Educational Research*, *10*(2), 124–141. https://doi.org/10.17275/per.23.32.10.2

Young, A. G., & Shtulman, A. (2020). How Children's Cognitive Reflection Shapes Their Science Understanding. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.01247