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Elementary Students' Difficulties in Adding Fractions: A Computational Thinking Analysis

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Abstract
This study analyzes elementary students' difficulties in understanding fraction addition through the framework of computational thinking (CT). Fractions are widely recognized as one of the most challenging mathematical concepts for young learners due to their abstract nature and multiple representations. The purpose of this study is to identify students' specific difficulties across the four CT dimensions; decomposition, pattern recognition, abstraction, and algorithmic thinking in the context of fractional addition. The research employed a qualitative descriptive design involving 19 sixth-grade students from an elementary school in Mojokerto, Indonesia. Data were collected through classroom observations, diagnostic tests, and semi-structured interviews. Findings show that 78.9% of students struggled with abstraction, 73.7% with decomposition, 68.4% with algorithmic thinking, and 63.2% with pattern recognition. Students frequently applied whole-number reasoning, failed to identify equivalence patterns, and were unable to construct systematic solution procedures. These results indicate that students' difficulties are multidimensional and stem from insufficient scaffolding in linking conceptual understanding with procedural fluency. The study suggests that CT-based instructional strategies can strengthen students' structural reasoning and support deeper learning of fraction concepts.

INTRODUCTION

Mathematics is one of the fundamental subjects in basic education that plays an important role in developing students' logical, critical, and systematic thinking skills. Nevertheless, math is often a subject that most elementary school students find difficult and daunting, especially in abstract material such as fractions. Understanding the concept of fractions is an important prerequisite for students to learn advanced mathematics materials, such as algebra, comparison, and statistics (Wiryanto & Jannah, 2022). Students' difficulties in understanding fractions not only have an impact on academic achievement in elementary school, but also affect their numeracy skills at the next level of education. Longitudinal research shows that mastery of fractional concepts in grade IV of elementary school is a strong predictor for success in learning algebra in secondary school (Ibrahim et al., 2023). Therefore, early identification of fractional learning difficulties and targeted remediation efforts are of utmost importance in the context of mathematics education. The complexity of fractional concepts involving an understanding of parts of the whole, relative sizes, and number operations requires an innovative and student-based approach to learning. In this context, the integration of *computational thinking* perspectives offers a systematic framework for understanding and overcoming students' difficulties in studying fractional operations.

Fractions are one of the most challenging math topics for elementary school students because of their abstract nature and involve multiple representations, both symbolic and visual. In contrast to integers that can be understood through everyday concrete experiences, fractions require an understanding of the concepts of proportion, comparison, and relationships between parts that are not always intuitive for students (Djatmika & Praherdhiono, 2024). Fraction summing operations, particularly fractions with different denominators, require a complex set of procedural steps, including finding the smallest common multiples, equalizing denominators, and simplifying results. Research shows that elementary school students often experience fundamental misconceptions in understanding fractions, such as thinking of fractions as two separate integers or applying integer operation rules directly to fractions (Copur-Gencturk, 2021). A common mistake found is that students add numerators by numerators and denominators by denominators without paying attention to the concept of fractional values. Factors influencing this difficulty include poor conceptual understanding, reliance on memorization of procedures, and limitations in visualization and fractional representation. In addition, the learning approach that emphasizes too much on procedural aspects without developing conceptual understanding also exacerbates this problem. The cognitive complexity of understanding fractions demands the development of learning strategies that can facilitate students to build deep and meaningful understanding.

Computational thinking (CT) is a framework of thinking that involves problem solving, system design, and understanding human behavior based on fundamental concepts of computer science. The concept of CT popularized by Jeannette Wing has become an important focus in 21st-century education reform due to its relevance to various disciplines, including mathematics (Nouri et al., 2020). In the context of mathematics learning, CT provides a systematic framework to help students develop logical, analytical, and algorithmic thinking skills that are essential in solving mathematical problems (Solihin et al., 2024). The four main pillars of CT that are relevant to mathematics learning are *decomposition* (the ability to break down complex problems into simpler parts), *pattern recognition* (the ability to identify patterns and regularities), *abstraction* (the ability to identify important information and ignore irrelevant details), and *algorithmic thinking* (the ability to design systematic steps to solve problems). Recent research shows that the integration of CT in mathematics learning can improve students' conceptual understanding, problem-solving skills, and knowledge transfer to new contexts (Fitriani et al., 2021). In fractional learning, CT can help students understand the structure of problems, identify patterns in fractional operations, abstract fractional concepts from concrete to symbolic representations, and develop systematic resolution algorithms. However, research on the application of the CT perspective in analyzing students' difficulties on fractional topics is still limited, especially in the context of basic education in Indonesia.

Various studies have identified the specific difficulties students experience in studying fractional surgery, but few have analyzed them from a CT perspective comprehensively. A study conducted by Powell & Nelson (2021) found that Indonesian students have difficulty visualizing fractions and associating pictorial representations with mathematical symbols, which indicates weak *abstraction* skills. Another study by Magdalena et al. (2020) showed that elementary school students in Indonesia tend to use procedural memorization strategies without understanding the reasoning behind each step, which reflects weaknesses in meaningful *algorithmic thinking*. From the perspective of *decomposition*, the research of Solihin et al. (2024) revealed that students have difficulty breaking down the problem of summing fractions with different denominations into simpler sub-problems, such as finding the KPK or changing the shape of the equivalent fraction. Meanwhile, in the aspect *of pattern recognition*, a study by Ibrahim et al. (2023) showed that students were unable to recognize the pattern of relationships between valuable fractions and had difficulty generalizing settlement strategies from one context to another. This research gap shows the need for research that specifically analyzes students' difficulties in summing fractions through a four-dimensional CT lens in an integrated manner. In addition, the unique cultural context and learning environment in Indonesia requires further investigation to produce findings that are contextual and applicable to the improvement of mathematics learning in primary schools.

The context of this research was conducted at SDN Pugeran, Gondang District, Mojokerto Regency, which is an elementary school in a semi-urban area with diverse student characteristics in terms of academic ability and socioeconomic background. Initial observations made by the researcher showed that grade IV students at the school still had significant difficulties in solving the problem of summing fractions, especially those involving different denominators. The results of the pre-research test showed that only 32% of students were able to solve the sum of different denominators problems correctly, while 68% of students made procedural or conceptual errors. Analysis of student errors indicates a systematic problem in the way students understand and solve fractional operations, which cannot be explained only from the perspective of mastery of the procedure. This phenomenon encourages researchers to analyze students' difficulties from a more comprehensive perspective, namely through a CT framework that can reveal the cognitive dimensions involved in fractional understanding. By identifying specific difficulties in each dimension of CT, this research is expected to make a theoretical and practical contribution to the development of more effective learning strategies. The findings of this research are also expected to be the basis for the development of CT-based digital learning media that is contextual with local culture, in line with the *ethnomathematics approach* that is increasingly receiving attention in Indonesian mathematics education.

Based on the background that has been described, this study aims to analyze in depth the difficulties of grade IV students of SDN Pugeran in understanding the concept of fraction summation from a *computational thinking perspective*. Specifically, this study is focused on identifying students' difficulties in the four dimensions of CT, namely *decomposition*, *pattern recognition*, *abstraction*, and *algorithmic thinking* in the context of summing fractions with different denominators. This study uses a descriptive qualitative approach with data triangulation methods through observation, diagnostic tests, and in-depth interviews to get a comprehensive picture of the difficulties experienced by students. The significance of this research lies in its contribution to the development of fractional learning theory that integrates the CT perspective, as well as its practical implications for the design of more effective learning interventions in primary schools. By understanding the specific difficulties of each CT dimension, teachers can design targeted scaffolding to help students develop a balanced conceptual and procedural understanding. In addition, the findings of this study are expected to be the foundation for the development of interactive digital learning media that integrates CT principles with the local cultural context, so that fractional learning becomes more meaningful and relevant for students. This research also contributes to the global discourse on the importance of CT literacy in basic mathematics education as a provision for students to face the challenges of the 21st century.

METHODS

This study uses a qualitative approach with a descriptive method to analyze students' difficulties in understanding the concept of fraction summation from a *computational thinking* perspective. The research subjects consisted of 19 grade IV students of SDN Pugeran, Gondang District, Mojokerto Regency, who were selected using *a purposive sampling technique* based on the results of a pre-research test that showed difficulties in solving fraction summation problems. Data were collected through three main methods, namely learning observation, written diagnostic tests, and semi-structured interviews. Observations were made during six math learning sessions to identify patterns of students' difficulties in the process of learning fractions naturally in the classroom. The diagnostic test was developed based on the four dimensions *of computational thinking* (decomposition, pattern recognition, abstraction, and algorithmic thinking) with a total of 12 questions each designed to reveal specific difficulties in each dimension. Semi-structured interviews were conducted with 8 students representing high, medium, and low ability levels based on diagnostic test results to explore a deep understanding of students' thinking processes in solving fractional problems. The research instrument was validated by two mathematics education experts and one *computational* *thinking* expert, then tested on 15 grade IV students from other schools with similar characteristics to ensure the reliability and readability of the instruments.

Data analysis was carried out using content analysis techniques with the Miles and Huberman approach which included three main stages, namely data reduction, data presentation, and conclusion drawn. At the data reduction stage, the researcher encodes student errors based on the four dimensions of CT using a coding system that has been developed deductively from the CT theory framework. Each student's error is categorized into one or more CT dimensions to identify the dominant pattern of difficulty. The results of the diagnostic test were analyzed quantitatively descriptively to calculate the percentage of errors in each CT dimension, then interpreted qualitatively by referring to observation and interview data. Interview transcripts were analyzed using *thematic analysis* techniques to identify the main themes that emerged related to students' difficulties in each dimension of CT. Data triangulation was carried out by comparing findings from the three data sources (observations, tests, and interviews) to ensure the validity and reliability of the research findings. To increase the credibility of the research, *member checking was also carried out* by showing the results of the interpretation to several informant students to verify the accuracy of the researcher's understanding of their statements. The data analysis process is carried out with the help of MAXQDA 2022 software to organize and code qualitative data systematically.

The validity of the data in this study is guaranteed through four main criteria, namely credibility, transferability, dependability, and confirmability. Credibility was strengthened through triangulation of sources and methods, *prolonged engagement* in the field for eight weeks, and *peer debriefing* with fellow mathematics education researchers to discuss findings and interpretations. Transferability is maintained by providing a *thick description* of the research context, subject characteristics, and data collection process so that the reader can assess the possible transferability of the findings to other similar contexts. Dependability is ensured through trail audits that document the entire research process from instrument development, data collection, to analysis and interpretation, as well as consistency in the application of data coding procedures. Confirmability is maintained by retaining all raw data, field notes, interview transcripts, and analytical documents to allow for external audits if needed. Research ethics are maintained by obtaining permission from the principal and consent from the student's parents prior to data collection, maintaining the confidentiality of students' identities by using initial codes, and ensuring that student participation is voluntary and that they can resign at any time without consequences. The entire research process is carried out taking into account the ethical principles of qualitative research, including respecting the autonomy of the subject, maximizing benefits and minimizing risks, and maintaining data integrity.

Table 1. Diagnostic Test Blueprint Based on Computational Thinking Dimensions

CT Dimension	Indicator	Item Number	Sample Question
Decomposition	Identifying the steps involved in adding fractions	1, 2, 3	"Explain the steps you take to calculate 1/3 + 1/4."
Pattern Recognition	Recognizing equivalent fraction patterns and relationships among fractions	4, 5, 6	"What is the relationship among 2/6, 3/9, and 4/12?"
Abstraction	Understanding the concept of fractional value without relying on specific contexts	7, 8, 9	"Which is greater: 3/5 or 2/3? Explain your reasoning without calculating."
Algorithmic Thinking	Constructing systematic procedures for adding fractions	10, 11, 12	"Write down the general steps for adding two fractions with different denominators."

RESULTS AND DISCUSSION

Results

The results of the analysis of diagnostic tests, learning observations, and in-depth interviews with 19 grade IV students of SDN Pugeran showed that students' difficulties in understanding the concept of fractional summation can be categorized into four main dimensions *of computational thinking*, namely *decomposition*, *pattern recognition*, *abstraction*, and *algorithmic thinking*. Of the entire study subjects, it was found that 84% of students (16 out of 19 students) had difficulty with at least two dimensions of CT, while 47% of students had difficulty with all dimensions. Quantitative data from diagnostic tests showed that the most problematic dimension was *abstraction* with an error rate of 78.9%, followed by *decomposition* (73.7%), *algorithmic thinking* (68.4%), and *pattern recognition* (63.2%). These findings indicate that students' difficulties are multidimensional and interrelated, where weaknesses in one dimension of CT often impact others. Further analysis of the error pattern showed that students with high abilities tended to have difficulty in the *abstraction* and *pattern recognition* dimensions, while students with low abilities experienced difficulties in all dimensions equally.

Difficulties in Decomposition Dimensions

The results showed that 73.7% of students had difficulty in breaking down the problem of summing fractions into sub-problems or simpler steps. Learning observations revealed that when faced with a question like "1/3 + 1/4", the majority of students immediately tried to find an answer without first identifying what to do. From the interview with the student with the initials AA, a statement was obtained: "I am confused Sir, where to start. Anyway, I just add the top number with the top number." This statement reflects the student's inability to break down the problem into logical steps such as identifying the difference in denominators, looking for the KPK, converting the fraction to an equal form, and then summing up. Analysis of test results on question number 2 that asked students to explain the completion steps showed that only 5 students (26.3%) were able to write down at least three correct and sequential steps. A total of 8 students (42.1%) only wrote one step in no clear order, such as "equalize the denominator" without explaining how to equalize it. The remaining 6 students (31.6%) could not write down the steps at all or wrote down the wrong steps, such as "add up all the numbers." Observational data also showed that students tended to panic when teachers asked them to explain the process of solving step by step, and preferred to memorize procedures without understanding the structure of the problem.

Table 2. Distribution of Students' Errors in the Decomposition Dimension

Type of Error	Number of Students	Percentage	Example of Error
Unable to identify the steps	6	31.6%	Directly adding the numerators and denominators
Writing steps out of sequence	8	42.1%	Equalizing denominators after performing addition
Skipping essential steps	11	57.9%	Failing to find the least common multiple (LCM) first
Not understanding the purpose of each step	14	73.7%	Following the procedure without comprehension

Furthermore, the analysis of errors in the *decomposition* dimension reveals three main difficulty patterns. First, students are unable to identify that the addition of fractions with different denominators requires the equalization of denominators as a prerequisite. Second, students have difficulty breaking down the KPK search process into simple steps such as making multiples of each denominator or using prime factorization. Third, students do not understand that each step in the procedure has specific interrelated objectives. An interview with a student with the initials DN revealed: "I know I have to equate the denominator, but I don't know what it's for. The teacher said so, so I just went along." This statement shows that students perform procedural steps without understanding the function of each step in the overall problem-solving process. This inability to *decomposition* has an impact on other dimensions of CT, because without a clear understanding of the structure of the problem, students will have difficulty in recognizing patterns, abstracting concepts, and compiling systematic algorithms.

Difficulties in Pattern Recognition Dimensions

In the *pattern recognition dimension*, 63.2% of students had difficulty in recognizing the pattern of relationships between fractions, especially the concept of equal fractions and patterns in fraction operations. Analysis of the test results on question number 4 which asked the relationship between fractions 2/6, 3/9, and 4/12 showed that only 7 students (36.8%) could identify that the three fractions were worth because they were all equal to 1/3. Most students, namely 10 students (52.6%), considered the three fractions to be different because the numbers were different, without understanding the concept of equivalence. The student with the initials RF stated in an interview: "The fractions are different, sir. 2/6 is different from 3/9 because the numbers are not the same." This statement reflects students' understanding that is still fixated on symbolic representations without understanding the value or meaning represented by the symbols. Learning observations also show that when teachers use visual media to demonstrate fractions of value, students can understand in that concrete context, but fail to transfer that understanding when presented in a purely symbolic form. This indicates that students have not developed the ability to recognize abstract patterns that connect various fractional representations.

Difficulties in recognizing patterns are also seen in students' ability to identify fractional operation patterns. When asked to solve a series of fraction summing questions with a similar pattern, only 5 students (26.3%) could recognize that the same strategy could be used for the questions. The majority of students, 14 students (73.7%), treated each question as a separate problem and started from scratch without capitalizing on patterns they had previously discovered. The student with the initials KA explained: "Every question has a different number, sir. So I did it one at a time from the beginning again." The inability to recognize these patterns causes the problem-solving process to become inefficient and students are unable to develop generalization strategies. Furthermore, an analysis of students' errors in question number 6 that asked them to predict the results of summing based on patterns showed that 68.4% of students could not see the regularity in the order of the fractions and the results. Interview data revealed that students are not used to looking for patterns or relationships in math learning, because learning emphasizes more on following the procedures taught by the teacher. These findings show the need to develop *pattern recognition* skills through explicit learning activities that teach students to find, identify, and utilize patterns in mathematical problem solving.

Difficulties in Dimension Abstraction

The *abstraction dimension* showed the highest level of difficulty with 78.9% of students having difficulty understanding abstract concepts of fractional values without being tied to a specific concrete context or representation. The test results on question number 7 that asked students to compare 3/5 and 2/3 without doing calculations showed that only 4 students (21.1%) could give a correct conceptual explanation, such as "2/3 is greater because it is closer to 1 whole" or "2/3 means less than 1/3 is full, while 3/5 is still less than 2/5." The majority of students, 12 students (63.2%), immediately did the calculation by equalizing the denominator without trying to understand the relative value of the fraction. The student with the initials MA stated: "I can't imagine Sir, which is bigger if it is not counted. You have to use numbers." This statement indicates that students are still heavily reliant on calculation procedures and have not yet developed a conceptual understanding of fractional quantities. The other three students (15.8%) gave incorrect answers with incorrect reasoning, such as "3/5 is greater because 3 is greater than 2" without considering the denominator. Learning observations show that students have difficulty when asked to explain the meaning of a fraction outside the context of a story or concrete picture, which shows weaknesses in mathematical abstraction skills.

A more in-depth analysis of the difficulties of abstraction reveals that students experience three main obstacles. First, students have difficulty separating fractional concepts from specific concrete representations, such as pictures of pizza or chocolate bars that are often used in learning. When presented with fractional problems without visual context, students lose their conceptual "anchor." Second, students are unable to abstract general principles from the specific cases they have studied. For example, after learning that 1/2 + 1/4 = 3/4 with an image, students cannot transfer that understanding to another fraction operation without an image. Third, students have not developed an internal mental representation of fractional values. An interview with a student with the initials SL revealed: "If there is a picture, I can do it, sir. But if it's just a number, I don't know what it means." Test data showed that 15 students (78.9%) were heavily reliant on external representations and had not yet developed the ability to work with purely symbolic representations. This reliance on concretization becomes a serious obstacle when students have to solve more complex or abstract fractional problems. These findings are in line with cognitive developmental theories that emphasize the importance of transitioning from concrete to abstract thinking in mathematics learning.

Table 3. Distribution of Students' Errors in the Abstraction Dimension

Type of Error	Number of Students	Percentage	Example of Error
Unable to understand the value of fractions without visual representation	15	78.9%	"I need a picture to know which one is bigger."
Applying whole-number logic to fractions	11	57.9%	"3/5 is greater because 3 is bigger than 2."
Unable to explain the meaning of fractions conceptually	16	84.2%	Cannot explain what 2/3 means
Fully dependent on computational procedures	12	63.2%	Always calculates even when estimation is possible

Difficulties in the Algorithmic Thinking Dimension

In the algorithmic *thinking dimension*, 68.4% of students had difficulty in compiling and following a systematic procedure to complete the sum of fractions independently. The results of the test on question number 10 that asked students to make general steps to add two fractions with different denominators showed that only 6 students (31.6%) were able to compile a complete and correctly ordered algorithm. The algorithm compiled by highly capable students generally includes steps: (1) identifying the denominator, (2) searching for the KPK, (3) converting the fraction to an equal form, (4) summing the numerator, (5) simplifying if necessary. However, the majority of students, 13 students (68.4%), compiled incomplete, insequential, or incorrect algorithms. An example of an algorithm that is wrong from a student with the initials RA: "1) Add a numerator, 2) Add a denominator, 3) If you can subtract, subtract." This algorithm is clearly conceptually wrong and reflects a fundamental misconception about fractional operations. Learning observations show that even though teachers have taught step-by-step procedures, students have difficulty internalizing and reproducing the procedures independently. An interview with a student with the initials FN revealed: "I forgot the order, sir. Sometimes I equalize the denominator first, sometimes I add first and then equalize."

Difficulties in *algorithmic thinking* are also seen in the inconsistency of students in applying the procedures they already know. An analysis of error patterns shows that a student can solve one problem correctly using the correct procedure, but fails to apply the same procedure to the next. Of the 19 students, 11 students (57.9%) showed inconsistencies in the application of the algorithm, indicating that they did not yet fully understand the logic behind each step. Students tend to follow procedures mechanically without an understanding of why each step is necessary. When faced with slightly different variations of the problem, such as the addition of three fractions at once, students are unable to adapt their basic algorithm. Interview data revealed that students considered each variation of the question to require a different procedure. The student with the initials LK stated: "If there are three fractions, the method must be different, sir. I don't know how." This inability to adapt and generalize algorithms suggests that the procedural learning they receive has not developed flexible and adaptive *algorithmic thinking*. Furthermore, an analysis of the efficiency of the algorithm used by students shows that even students who can solve problems correctly tend to use inefficient measures, such as searching for KPK by trial and error rather than using systematic methods.

Table 4. Summary of Students' Difficulties Based on Computational Thinking Dimensions

CT Dimension	Difficulty Percentage	Main Manifestation of Difficulty	Impact on Learning
Decomposition	73.7%	Unable to break down problems into simple steps	Students do not understand the structure of the problem
Pattern Recognition	63.2%	Unable to recognize equivalent fractions and operational patterns	Unable to generalize problem-solving strategies
Abstraction	78.9%	Highly dependent on concrete representations	Difficulty solving abstract and complex problems
Algorithmic Thinking	68.4%	Unable to construct systematic procedures	Inconsistency in problem-solving processes

Interrelationships Between CT Dimensions in Student Difficulties

Cross-dimensional analysis revealed that students' difficulties in the four dimensions of CT do not stand alone, but rather are interrelated and affect each other. Of the 19 students, 9 students (47.4%) had difficulty in all dimensions, 7 students (36.8%) had difficulty in three dimensions, and only 3 students (15.8%) had difficulty in two dimensions or less. The pattern that emerges suggests that weaknesses in *the abstraction* dimension tend to cause difficulties in other dimensions. Students who cannot abstract the concept of fractions also have difficulty *recognizing patterns*, because pattern recognition requires the ability to see the essential similarities behind surface differences. Similarly, weaknesses in *decomposition* have an impact on *algorithmic thinking*, as effective algorithms require an understanding of how complex problems can be broken down into simpler sub-problems. An interview with a low-ability student with the initials AS revealed: "I was confused from the beginning, sir. I don't know where to start, I don't know what the question means, I don't know how." This statement reflects the multidimensional difficulties that are intertwined.

Another interesting finding is that students with high abilities who can solve fraction problems correctly still show weaknesses in the aspects of *abstraction* and *pattern recognition*. Out of 5 highly capable students, 4 students (80%) were able to apply procedures correctly (*algorithmic thinking*) and solve problems correctly (*decomposition*), but when asked to explain concepts or recognize patterns, they had a hard time. The student with the initials DW who is classified as highly capable stated: "I can do the problem, sir, but if I am told to explain why it is, I can't." This phenomenon indicates that learning that emphasizes too much on procedural aspects can produce students who are able to solve problems but do not understand concepts in depth. Correlation analysis showed a strong relationship between *abstraction* ability and *pattern recognition ability* (r = 0.72), indicating that these two dimensions reinforce each other in the understanding of fractional concepts. Meanwhile, the correlation between *decomposition* and *algorithmic thinking* was also high (r = 0.68), suggesting that problem-solving skills are an important foundation for the development of effective algorithmic thinking.

Discussion

The findings of this study confirm that students' difficulties in understanding the sum of fractions are multidimensional and complex, in line with the results of previous research conducted by Ibrahim et al. (2023) which found that understanding fractions involves various interrelated cognitive aspects.

The *computational thinking perspective* provides a comprehensive analytical lens for understanding students' difficulties because this framework covers fundamental aspects of mathematical problem solving, from understanding the structure of problems to formulating systematic solutions. The high percentage of difficulties in the *abstraction* dimension (78.9%) indicates that fractional learning in elementary school is still highly dependent on concrete approaches without developing an adequate bridge to abstract understanding. Research by Siswono et al. (2020) shows that the transition from concrete to abstract understanding is a major challenge in fractional learning and requires structured scaffolding. Students' reliance on visual representations and concrete context reflects their stage of cognitive development, but it also points to weaknesses in learning designs that do not explicitly facilitate the process of abstraction. These findings confirm the importance of a learning approach that not only uses concrete manipulatives, but also systematically guides students to develop mental representations and symbolic understanding. The integration of digital technology can be a solution to provide multiple representations that can help students make connections between concrete, pictorial, and symbolic representations more effectively.

The difficulties in *the decomposition dimension* experienced by 73.7% of students indicate that fractional learning needs to place more emphasis on developing problem analysis skills before jumping into the resolution procedure. These findings are in line with the research of Supiarmo & Susanti (2021) which found that Indonesian students tend to directly apply procedures without first understanding the structure of the problem. In the context of *computational thinking*, *decomposition* is an important foundation because it allows students to break down complex problems into sub-problems that are more manageable. The students' inability to identify that the sum of different denominator fractions requires the equalization step of denominators indicates that they have not yet developed a structural understanding of fractional operations. Christi & Rajiman (2023) emphasize that *decomposition* is not just a procedural skill, but a mathematical way of thinking that involves analysis, identification of important components, and an understanding of how these components are interconnected. The pedagogical implications of these findings are the need to explicitly teach *decomposition* strategies through modeling, think-aloud protocols, and guided practices that help students develop analytical thinking habits. Teachers need to get students used to always identifying "what knows" and "what is asked" and planning a completion strategy before starting the calculations.

The low ability of students in *pattern recognition* (63.2%) reflects the limitations of learning that do not develop students' ability to see relationships and regularity in mathematics. Research by Habibah et al. (2022) found that Indonesian students are rarely trained to look for and identify patterns in mathematics learning because the curriculum and learning practices place more emphasis on mastering procedures. In fact, the ability to recognize patterns is the essence of mathematical thinking and is the basis for the development of generalization and proof skills at the next level of education. The inability of students to recognize that fractions such as 2/6, 3/9, and 4/12 are equal values shows that the concept of fractional equivalence has not been understood as a proportional relationship. Students are still fixated on surface differences (different numbers) without being able to abstract structural similarities (same ratios). Susanti (2025) suggests the use of learning activities that explicitly teach students to find, identify, describe, and utilize patterns in problem solving. A *pattern-based learning* approach that integrates technology can help students visualize patterns, explore different representations, and make connections between mathematical concepts. In addition, problem-based learning that encourages students to discover patterns on their own can develop a mathematical disposition to seek regularity and structure in any mathematical situation they encounter.

Difficulties in *algorithmic thinking* experienced by 68.4% of students revealed that although procedural learning has been emphasized, students have not developed a deep understanding of the logic behind the procedure. This finding is paradoxical but important because it shows that the emphasis on procedures without conceptual understanding does not result in solid mastery of procedures. Alam & Mohanty (2024) explain that effective *algorithmic thinking* is not just memorizing the steps, but understanding the principles underlying each step so that it can be applied flexibly to various situations. Students' inconsistencies in applying the procedures they already know reflect learning that is surface learning rather than deep learning. Students follow the procedure mechanically without understanding the "why" each step is necessary, so when faced with a variety of questions, they are unable to adapt their basic algorithm. Putro et al. (2023) emphasize that mathematical algorithm learning needs to integrate conceptual understanding with procedural skills through a balanced approach between exploration, discovery, and guided practice. The use of flowcharts or flowcharts can help students visualize the structure of the algorithm and understand the logic of decisions in each step. Further, debugging or error analysis activities can develop students' ability to evaluate and improve their own algorithms.

The interrelationships between CT dimensions found in this study provide important insights into the holistic nature of mathematical understanding. The finding that weaknesses in one dimension of CT tend to affect other dimensions is in line with mathematical cognition theories that emphasize that mathematical understanding is integrated and multidimensional (Doronina, 2021). The high correlation between *abstraction* and *pattern recognition* suggests that the ability to abstract essential concepts is a prerequisite for recognizing structural patterns. Students who are fixated on concrete details will have a hard time seeing the similarities in patterns behind surface differences. Similarly, the correlation between *decomposition* and *algorithmic thinking* indicates that an understanding of the structure of the problem is the foundation for developing a systematic solution strategy. Andrews et al. (2021) explain that the four dimensions of CT are not separate components, but rather mutually reinforcing aspects in the problem-solving process. The pedagogical implication of these findings is that learning interventions should not focus only on one dimension of CT, but need to be designed holistically to develop all dimensions in an integrated manner. A context-rich and challenging problem-based learning approach can provide an opportunity for students to develop all dimensions of CT simultaneously in the context of authentic problem-solving.

The phenomenon that highly capable students who can solve problems correctly still struggle in the conceptual aspect reveals serious limitations in the learning approach that overemphasizes procedures. These findings are in line with research by Polman et al. (2021) which found a gap between procedural skills and conceptual understanding in Indonesian students. Students can memorize and apply procedures to get the correct answers, but they don't understand the mathematical meaning of what they're doing. In the long run, procedural understanding without a strong conceptual foundation will be a serious obstacle when students are faced with more complex mathematical concepts or non-routine problem-solving situations. Hilz et al. (2023) emphasize that conceptual and procedural understanding must be developed in a balanced and mutually reinforcing manner through a learning approach that integrates concept exploration with procedural practice. Teachers need to explicitly connect the procedure with the underlying concept through reflective questions, class discussions, and activities that encourage students to explain their thinking. Assessments also need to be reformed to not only assess students' ability to solve problems, but also their ability to explain, justify, and apply concepts in diverse contexts. Siswanto (2024) suggests the use of a holistic rubric that assesses all dimensions of mathematical comprehension, including aspects of CT in problem solving.

The practical implications of the findings of this study for the professional development of primary school mathematics teachers are significant. Teachers need to be equipped with an understanding of *computational thinking* frameworks and how to integrate them in mathematics learning. This research shows that teachers need to change their approach to learning from one that focuses on procedure transfer to one that develops students' computational thinking skills. Polman et al. (2021) emphasize that the professional development of teachers needs to include not only knowledge of mathematics content and pedagogy, but also an understanding of students' cognitive processes in learning mathematics. Teacher workshops and training need to be designed to help teachers understand the four dimensions of CT, recognize the manifestations of student difficulties in each dimension, and design learning activities that explicitly develop each dimension. Teachers also need to be trained in using questioning strategies that encourage students to explain their thinking, identify patterns, abstract concepts, and evaluate their algorithms. Rambung et al. (2023) suggest the formation of a teacher professional learning community focused on the development of CT-based learning, where teachers can share best practices, discuss challenges, and develop shared learning resources. Furthermore, education policies need to support sustainable teacher professional development by providing adequate time, resources, and incentives.

CONCLUSION

This study confirms that the difficulties of grade IV students of SDN Pugeran in understanding the concept of summation of fractions are multidimensional and can be analyzed comprehensively through the perspective *of computational thinking*. The main findings showed that the majority of students had difficulty in all four dimensions of CT with the highest level of difficulty in *the abstraction* dimension (78.9%), followed by *decomposition* (73.7%), *algorithmic thinking* (68.4%), and *pattern recognition* (63.2%). These difficulties are interrelated and affect each other, with weaknesses in the *abstraction* dimension being the root of the problem that impact the other dimension. This study also reveals an important phenomenon that procedural skills are not always accompanied by adequate conceptual understanding, even in highly capable students. An in-depth analysis of the manifestations of difficulty in each dimension of CT provides valuable insights into students' cognitive processes in learning fractions and identifies specific areas that require pedagogical intervention. The findings of this study confirm the relevance and importance of integrating *computational thinking perspectives* in elementary school mathematics learning, especially in fractional materials that require logical, systematic, and abstract thinking skills. The theoretical contribution of this research lies in the development of a CT-based mathematics learning difficulty analysis framework that can be applied to other mathematics topics. The practical contribution of this research is the identification of specific difficulties that can be the basis for the development of more effective learning strategies, learning media, and assessments in developing students' conceptual and procedural understanding in a balanced manner.

Based on the findings of this study, several recommendations were put forward for improving fractional learning in elementary schools. First, fractional learning needs to be systematically designed to develop the four dimensions of CT in an integrated manner through an approach that balances conceptual exploration with procedural practice. Second, teachers need to use learning strategies that explicitly teach *decomposition*, *pattern recognition*, *abstraction*, and *algorithmic thinking skills* through modeling, think-aloud protocol, and guided practice. Third, the development of interactive digital learning media based on CT that integrates the local cultural context (*ethnomathematics*) is highly recommended to provide a rich, meaningful, and contextual learning experience for students. Such media can include virtual manipulatives, visualization of interactive patterns, multiple representations that can be transformed, and simulations of cultural contexts that involve the use of fractions in everyday life. Fourth, assessments need to be reformed to not only measure procedural skills, but also students' conceptual understanding and computational thinking skills through a holistic rubric that assesses all dimensions of CT. Fifth, teacher professional development programs need to be designed to improve teachers' understanding of CT and how to integrate it in mathematics learning, including training in diagnosing specific difficulties on each CT dimension and designing targeted scaffolding. Sixth, further research is urgently needed to test the effectiveness of CT-based learning interventions through experimental studies, explore the application of CT perspective to other fractional operations and other mathematical topics, and develop and validate CT-based diagnostic instruments that can be used by teachers practically. Seventh, education policies need to support the integration of CT in elementary school mathematics curriculum by providing implementation guidelines, learning resources, and adequate support systems for teachers. The implementation of these recommendations is expected to improve the quality of fractional learning and develop students' computational thinking skills that are essential for their success in advanced mathematics learning and facing the challenges of the 21st century.

REFERENCES

Alam, A., & Mohanty, A. (2024). Unveiling the complexities of 'Abstract Algebra' in University Mathematics Education (UME): fostering 'Conceptualization and Understanding' through advanced pedagogical approaches. *Cogent Education*, *11*(1), 2355400. https://doi.org/10.1080/2331186X.2024.2355400

Andrews, P., Bødtker Sunde, P., Nosrati, M., Petersson, J., Rosenqvist, E., Sayers, J., & Xenofontos, C. (2021). Computational estimation and mathematics education: A narrative literature review. *Journal of Mathematics Education*, *14*(1), 6–27.

Christi, S. R. N., & Rajiman, W. (2023). Pentingnya Berpikir Komputasional dalam Pembelajaran Matematika. *Journal on Education*, *5*(4), 12590–12598.

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.

Djatmika, E. T., & Praherdhiono, H. (2024). Belajar Matematika Lebih Menyenangkan: Pengembangan Multimedia Interaktif berbasis Gamifikasi untuk Operasi Bilangan Bulat. *Didaktika: Jurnal Kependidikan*, *13*(4 Nopember), 5045–5060.

Doronina, I. N. (2021). Interactive learning and its methodology. *Asian journal of multidimensional research*, *10*(5), 653–655.

Fitriani, W., Suwarjo, S., & Wangid, M. N. (2021). Berpikir Kritis dan Komputasi: Analisis Kebutuhan Media Pembelajaran di Sekolah Dasar. *Jurnal Pendidikan Sains Indonesia*, *9*(2), 234–242. https://doi.org/10.24815/jpsi.v9i2.19040

Habibah, H., Zulkarnain, I., & Budiarti, I. (2022). Eksplorasi Etnomatematika Konsep Geometri Pada Pola Gerak Tari Tradisional Banjar Baksa Kembang. *EDU-MAT: Jurnal Pendidikan Matematika*, *10*(2), 266–279.

Hilz, A., Guill, K., Roloff, J., Sommerhoff, D., & Aldrup, K. (2023). How to Continue? New Approaches to Investigating the Effects of Adaptive Math Learning Programs on Students' Performance, Self-Concept, and Anxiety. *Journal of Intelligence*, *11*(6), 108. https://doi.org/10.3390/jintelligence11060108

Ibrahim, F., Hendrawan, B., & Sunanih, S. (2023). Pengembangan Media Pembelajaran PACAS Untuk Meningkatkan Hasil Belajar Siswa. *JLEB: Journal of Law, Education and Business*, *1*(2), 102–108. https://doi.org/10.57235/jleb.v1i2.1192

Magdalena, I., Wizy Astuty, H., Valentina, F. R., Devita, N., & Tangerang, U. M. (2020). Penanganan Kasus Kesulitan Belajar Matematika Pada Kelas VI SDN Karawaci Baru 4. In *PENSA : Jurnal Pendidikan dan Ilmu Sosial* (Vol. 2, Nomor 1). https://ejournal.stitpn.ac.id/index.php/pensa

Nouri, J., Zhang, L., Mannila, L., & Norén, E. (2020). Development of computational thinking, digital competence and 21st century skills when learning programming in K-9. *Education Inquiry*, *11*(1), 1–17.

Polman, J., Hornstra, L., & Volman, M. (2021). The meaning of meaningful learning in mathematics in upper-primary education. *Learning Environments Research*, *24*(3), 469–486. https://doi.org/10.1007/s10984-020-09337-8

Powell, S. R., & Nelson, G. (2021). University students' misconceptions about rational numbers: Implications for developmental mathematics and instruction of younger students. *Psychology in the Schools*, *58*(2), 307–331. https://doi.org/10.1002/pits.22448

Putro, A. N. S., Wajdi, M., Siyono, Perdana, A. N. C., Saptono, Fallo, D. Y. A., Khoirotunnisa, A. U., Ningtyas, Kma. W. A., Leuwol, F. S., Pationa, S. B., Kumalasanti, R. A., & Setiyatna, H. (2023). Revolusi Belajar Di Era Digital. In *Revolusi Belajar Di Era Digital*.

Rambung, O. S., Sion, Bungamawelona, Puang, Y. B., & Salenda, S. (2023). Transformasi Kebijakan

Pendidikan Melalui Implementasi Kurikulum Merdeka Belajar. *Jurnal Ilmu Pendidikan*, *1*(3), 598–612. https://jip.joln.org/index.php/pendidikan/article/view/63

Siswanto, E. (2024). *Kemampuan Pemecahan Masalah pada Pembelajaran Matematika : Systematic Literature Review*. *8*, 45–59.

Siswono, T. E., Mawanto, A., & Lukito, A. (2020). Pengembangan Media Cerita Bergambar untuk Melatih Kemampuan Berpikir Kreatif Siswa Pada Materi Pecahan Kelas II. *Jurnal Cendekia : Jurnal Pendidikan Matematika*. https://api.semanticscholar.org/CorpusID:225768266

Solihin, A., Habibie, R. K., & Rahmawati, I. (2024). Computational Thinking with the Guided-Discovery-Learning Model Using Ethnomathematics-Based LKPD. EDM in Elementary School. *DIDAKTIKA: Jurnal Pendidikan Sekolah Dasar*, *7*(1), 80–93. https://doi.org/10.21831/didaktika.v7i1.75845

Supiarmo, M. G., & Susanti, E. (2021). Proses berpikir komputasional siswa dalam menyelesaikan soal pisa konten change and relationship berdasarkan self-regulated learning. *Numeracy*, *8*(1), 58–72.

SUSANTI, E. (2025). ENHANCING PROBLEM-SOLVING SKILLS IN ELEMENTARY STUDENTS THROUGH REALISTIC MATHEMATICS EDUCATION. *SCIENCE : Jurnal Inovasi Pendidikan Matematika dan IPA*, *5*(1), 48–59. https://doi.org/10.51878/science.v5i1.4344

Wiryanto, & Jannah, M. (2022). *Pengembangan Media Kartu Domino Hitung Matematika-Kode Quick Response (KOMIKA-QR) Pada Materi Pecahan Siswa Sekolah Dasar*.