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Analysis of Contextual Problem-Solving Instruction in the Construction of Elementary Students' Mathematical Conceptual Understanding

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ABSTRACT

Purpose – This study aims to analyze contextual problem-solving instruction as a pedagogical space for constructing elementary students' mathematical conceptual reasoning in whole-number learning. The study focuses on how authentic problems, everyday-life contexts, and instructional interaction facilitate students' construction of conceptual meaning and their explanation of the rationale for using arithmetic operations.

Methodology – This study employed a field-based qualitative case study approach. Researchers collected data through classroom observations, interviews with the school principal, teacher, and selected students, document analysis, and pretest–posttest measures as supporting descriptive data. Data were analyzed through data reduction, data display, and conclusion drawing, while trustworthiness was ensured through source, technique, and time triangulation.

Findings – The findings show that contextual problem-solving instruction created a learning space that enabled students to actively, reflectively, and meaningfully construct mathematical conceptual reasoning. Through simple buying-and-selling contexts, the use of play money, group discussion, and reflection, students were able to identify information, select solution strategies, explain the rationale for using addition and subtraction, and relate whole-number concepts to real-life situations.

Contribution – This study confirms that contextual problem-solving instruction should be understood not merely as a strategy for improving learning outcomes, but as a pedagogical space that facilitates the construction of students' mathematical conceptual reasoning through authentic experience, social interaction, and reflection on thinking processes.

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INTRODUCTION

Mathematics education at the elementary school level plays a fundamental role, as it is during this stage that students develop the foundations of knowledge, learning dispositions, and patterns of thinking that will influence their academic success at subsequent levels. In contemporary discourse, mathematics learning is no longer understood merely as the mastery of computational procedures, but rather as a process of developing conceptual understanding that enables students to explain the meaning of mathematical ideas, establish connections across concepts, and apply them logically in new situations. Recent literature indicates that problem-based learning and authentic contexts have the potential to deepen conceptual understanding, enhance motivation, and strengthen student engagement in mathematics learning (Ayari et al., 2025; Budiman et al., 2025).

This study is grounded in the central problem of fourth-grade mathematics learning at SDN Bumiaji 2, Batu City: students' weak conceptual understanding, particularly in whole-number topics. This condition is associated with instructional practices that remain dominated by teacher-centered approaches and procedural training, leading students to follow solution steps without fully understanding the underlying mathematical meaning. The manuscript also indicates that students experience difficulty when problems are linked to everyday contexts, while initial learning outcomes show a predominance of performance in the poor and fair categories. These findings suggest a gap between the mathematical concepts taught in the classroom and students' concrete experiences as the basis for meaning construction (Suhermi et al., 2025; Nurhaswinda et al., 2025). Accordingly, the problem addressed in this study concerns not only low learning outcomes but also the limited effectiveness of instruction in facilitating the active, contextual, and meaningful construction of mathematical understanding.

One relevant approach to addressing this issue is problem-solving-based instruction. Theoretically, this approach positions problems as the entry point to learning and requires students to identify information, devise strategies, implement solutions, and reflectively review results. Sari et al. (2021) found that students' understanding of the problem-solving process has a positive and significant effect on mathematics learning outcomes. Similarly, the systematic review by Ayari et al. (2025) confirms that problem-based learning in K–12 mathematics education has developed into an approach that connects concepts to authentic situations to promote conceptual understanding, critical thinking, and learning motivation. In this context, the problem-solving model is important not only for helping students obtain answers but also for creating opportunities for them to understand why a particular operation is used and how solution strategies are constructed (Sa'diah & Nahdi, 2023).

However, problem-solving cannot function optimally if the problems presented remain abstract and detached from students' experiential worlds. It is at this point that the Contextual Teaching and Learning (CTL) approach becomes particularly significant. The use of simple buying-and-selling contexts and play money in whole-number learning enables students to relate arithmetic operations to practices familiar from everyday life (Surata & Marhaeni, 2019). This direction is consistent with Yunitasari et al. (2023), who showed that implementing CTL in elementary mathematics can improve learning outcomes while reducing mathematics anxiety. The findings of Budiman et al. (2025) further demonstrate that contextual teaching supported by manipulative media strengthens conceptual understanding, engagement, motivation, and creativity among elementary school students. Thus, context in this study functions not merely as illustration, but as an epistemic medium through which mathematical concepts can be understood in more meaningful and applicable ways.

Conceptually, integrating problem-solving and CTL reflects a strong constructivist orientation, positioning students as active agents who build knowledge through experience, discussion, and reflection (Ariyani et al., 2025). This perspective is consistent with constructivist theory, which emphasizes that knowledge is actively constructed by learners through experience and interaction (Rindana & Panggabean, 2022). Previous studies have shown that problem-based learning and contextual approaches each contribute positively to mathematics learning. Nevertheless, most of these studies have examined the two approaches separately, or have focused primarily on general learning outcomes, problem-solving ability, critical thinking, or mathematics anxiety rather than on the construction of conceptual understanding as the central objective of elementary mathematics instruction. In addition, limited attention has been given to how contextual problem-solving instruction operates as a pedagogical space through which students actively construct conceptual meaning in whole-number learning. Despite these findings, how contextual problem-solving supports the construction of mathematical conceptual understanding in elementary classrooms remains insufficiently explored, particularly with respect to the roles of authentic contexts, instructional interaction, and students' active engagement. Therefore, the novelty of this study lies in analyzing contextual problem-solving instruction not merely as a learning strategy, but as a pedagogical space for constructing students' conceptual understanding in whole-number learning.

Against this background, this study aims to analyze contextual problem-solving instruction as a pedagogical space for constructing elementary students' mathematical conceptual understanding in whole-number learning. More specifically, the study seeks to examine how authentic problems, everyday-life contexts, and classroom interaction facilitate students' construction of conceptual meaning and their explanation of the rationale for using arithmetic operations. In line with this objective, the research is guided by the following question: How do authentic problems, everyday-life contexts, and classroom interaction facilitate the construction of students' mathematical conceptual understanding in whole-number instruction? By addressing this question, the study is expected to contribute both theoretically to the discourse on meaningful mathematics learning and practically to the development of more relevant, participatory, and student-centered mathematics instruction in elementary classrooms.

METHODOLOGY

Research Design

This study used a qualitative case study design. We selected this design because our research focused on a bounded case: implementing contextual problem-solving instruction in a single fourth-grade classroom at SDN Bumiaji 02, Batu City, during whole-number learning. A case study is appropriate when the researcher seeks to understand a contemporary phenomenon within its real-life setting and when the boundaries between the phenomenon and the context are closely intertwined (Yin, 2018). In line with Creswell and Poth (2018) and Merriam and Tisdell (2016), the present study did not aim to test causal relationships or generate statistical generalizations; rather, it aimed to produce an in-depth understanding of instructional processes, classroom interaction, participant responses, and the construction of conceptual meaning in a natural school setting. Therefore, this study can be categorized as a single-case qualitative case study because it examined one bounded classroom context in depth rather than comparing multiple cases across different schools or classrooms.

Participant

The study was conducted from August to October 2025 in one fourth-grade classroom at SDN Bumiaji 02, Batu City. The bounded case involved one classroom teacher as the key instructional actor, one school principal as a contextual informant, and 25 fourth-grade students as classroom participants. Within this case, the teacher and principal were interviewed as key informants, while selected students were interviewed as supplementary informants to capture learning experiences from the learner perspective. Focusing on one class is methodologically acceptable in qualitative case study research because the goal is depth of contextual understanding rather than breadth of sample coverage. The class was considered sufficient because it represented the actual setting in which the contextual problem-solving model was implemented intensively and observed directly across the learning process (Yin, 2018; Merriam & Tisdell, 2016).

Data Collection

We collected data through classroom observation, interviews, document analysis, and pretest–posttest measures, utilizing the testing instruments solely for descriptive purposes. We conducted classroom observations during the learning process to record how the teacher introduced contextual problems, how students understood tasks, how they selected strategies, how discussions developed, and how the instructor facilitated reflection and participation. Interviews were conducted with the principal, the classroom teacher, and selected students to obtain information on school support, instructional planning, learning experiences, and implementation challenges. Document analysis covered teaching modules, students' work, field notes, and visual documentation as evidence of how the learning process unfolded. The combination of these techniques enabled the study to capture the process dimension, participant perspective, and documentary trace of the same instructional event (Chand, 2025; Xu et al., 2025).

Qualitative data were analyzed using an interactive analysis model involving data condensation, data display, and conclusion drawing. The analysis began by coding observation notes, interview transcripts, and documents to identify recurring patterns in students' conceptual understanding, problem-solving processes, and classroom interactions. We then organized these codes into categories and themes, interpreting them to explain how students constructed conceptual understanding during the learning process. To ensure the credibility of the findings, data triangulation was conducted across observation, interviews, and documentation.

The pretest and posttest were not treated as the main basis of analysis and were not used for hypothesis testing. Instead, the pretest and posttest functioned as complementary descriptive evidence to illustrate general trends in students' conceptual understanding before and after the classroom implementation. The results were presented as score distributions or simple comparisons, without inferential statistical analysis. This clarification ensures the consistency of the study's qualitative paradigm while still using the numerical information available in the classroom context.

Instrument

The research instruments included an observation guide, interview protocols, a document analysis guide, and a written test. The observation guide focused on instructional stages, student participation, teacher facilitation, and the use of contextual media. The interview protocols were tailored for the principal, the teacher, and the students. The document-analysis guide focused on lesson plans or teaching modules, students' written work, observation notes, and classroom photographs. The written test used for the pretest and posttest consisted of five open-ended items on whole-number material. The items were designed to assess students' ability to identify information in a problem, determine appropriate operations, perform calculations, explain the reasons for using addition or subtraction, and relate the solution to the given context. Student responses were scored analytically and then converted to a 0–100 scale for descriptive categorization.

Although the written test involved numerical scoring, it was not intended for statistical measurement or hypothesis testing, but rather to provide descriptive support for interpreting students' conceptual understanding within the qualitative framework. The pretest and posttest were not used as a basis for hypothesis testing; instead, they functioned as complementary descriptive evidence to illustrate general trends in students' conceptual understanding before and after the classroom implementation.

Data Analysis

Qualitative data from observation, interviews, and documents were analyzed using the interactive model of Miles, Huberman, and Saldaña (2014), which includes data collection, data reduction, data display, and conclusion drawing/verification. The researcher first organized the field data, selected information relevant to the research focus, grouped it into meaningful categories, narrated the patterns, and then drew conclusions by continuously comparing findings across sources (Miles et al., 2014; Dahal, 2025). Because the study was designed as a qualitative case study, the analysis focused on the instructional process, participant responses, and the construction of conceptual understanding within the case.

The analytical framework used descriptive statistics to evaluate the pretest and posttest data. First, each student's answer was scored using an analytic rubric and converted into a 0–100 score. Second, students were grouped into score categories to allow the distribution of conceptual understanding before and after implementation to be described transparently. The percentage for each category was calculated using the formula $P = (f/N) \times 100\%$, where f is the number of students in a category, and N is the total number of students. The score categories used in this study are presented in Table 1 and were adapted from the commonly used educational evaluation criteria proposed by Arikunto (2013). These numerical data were used only to support the qualitative interpretation and not to produce inferential claims.

Table 1. Score-category criteria used in the descriptive analysis

Score interval	Category
0–20	Very poor
21–40	Poor
41–60	Fair
61–80	Good
81–100	Very good

Source: Adapted from Arikunto (2013).

To ensure trustworthiness, the study employed source, technique, and time triangulation. Source triangulation compared information from the principal, teacher, students, and classroom documents. Technique triangulation compared evidence from observation, interview, document analysis, and descriptive test data. Time triangulation validated the findings by examining data from the beginning, middle, and end of the instructional process. These procedures are consistent with qualitative research standards emphasizing credibility, transparency, and careful cross-checking of evidence (Ahmed, 2024; Lochmiller et al., 2026).

FINDINGS

Initial Condition of Students' Conceptual Understanding

The initial classroom condition indicated that many fourth-grade students had not yet demonstrated strong conceptual understanding of whole numbers. Before implementing the contextual problem-solving model, the teacher administered a pretest to 25 students using the five-item written test described in the method section. The descriptive results showed that 3 students (12%) were in the very poor category, 10 students (40%) were in the poor category, 8 students (32%) were in the fair category, 2 students (8%) were in the good category, and 2 students (8%) were in the very good category. This pattern indicates that most students were still concentrated in the lower and middle categories, especially when they were required to interpret mathematical situations presented in story or transaction form. This distribution is presented in Table 2.

Table 2. Distribution of students' pretest results by score category

Category	Frequency (Students)	Percentage
Very poor	3	12%
Poor	10	40%
Fair	8	32%
Good	2	8%
Very good	2	8%
Total	25	100%

Development of Conceptual Understanding During Learning

A major finding of the study is a change in how students interpret arithmetic operations. Throughout the instructional process, students engaged not only in calculations but also in explaining the conceptual necessity of specific mathematical operations. In the transaction simulation, students could state that addition was used to combine item prices into a total payment, whereas subtraction was used to determine change after payment. Observation notes and students' written work show that several students moved from simply following steps to articulating the conceptual function of the operation used. Student interview data further indicate that contextual tasks helped them connect classroom mathematics to familiar daily transactions, so the tasks no longer appeared purely abstract.

Affective and Social Responses of Students

The findings also show changes in the affective and social climate of learning. Compared with the preliminary condition, students became more enthusiastic in participating, more willing to ask and answer questions, and more confident when presenting their work. Group discussion was more active because students had to negotiate item choices, payment totals, and change calculations together. Interview data from students suggest that learning through play money and transaction scenarios felt easier to follow than listening to an explanation alone. The teacher interview further revealed that passive students were more willing to engage when faced with familiar, manipulable tasks. One student stated, "Learning with play money makes it easier for me to understand because it feels like real-life buying and selling, not just numbers." This statement illustrates that contextual media helped students experience mathematics as a concrete, understandable activity rather than an abstract calculation task.

Descriptive Shift in Pretest and Posttest Distribution

The descriptive posttest results indicate a clear shift in the distribution of categories after the implementation of contextual problem-solving instruction. No students remained in the very poor category. The poor category decreased from 40% to 8%, and the fair category decreased from 32% to 12%. In contrast, the good category increased from 8% to 48%, while the very good category increased from 8% to 32%. When the category distributions before and after implementation are compared, the classroom data show a 64% cumulative shift from the lower categories toward the good and very good categories. Because these data were used descriptively, the significance of this result lies not in statistical inference but in its support for the qualitative finding that students' conceptual understanding improved during the learning process. The comparison is presented in Table 3.

Table 3. Comparison of pretest and posttest distributions

Category	Pretest	Posttest	Change
Very poor	12% (3 students)	0% (0 students)	-12%
Poor	40% (10 students)	8% (2 students)	-32%
Fair	32% (8 students)	12% (3 students)	-20%
Good	8% (2 students)	48% (12 students)	+40%
Very good	8% (2 students)	32% (8 students)	+24%

Source: Processed classroom data from the pretest and posttest administered to 25 students.

Implementation Challenges Within the Case

Although the implementation produced positive changes, the case also revealed several classroom challenges. Some students still needed guidance in identifying the relevant information in the problem and choosing an appropriate solution strategy. The learning process also required more time than a conventional explanation because students had to discuss ideas, test them, present their work, and reflect on the solution. Observation and teacher interview data show that the model's success depended heavily on the teacher's ability to manage time, ask guiding questions, and provide support without immediately taking over students' thinking.

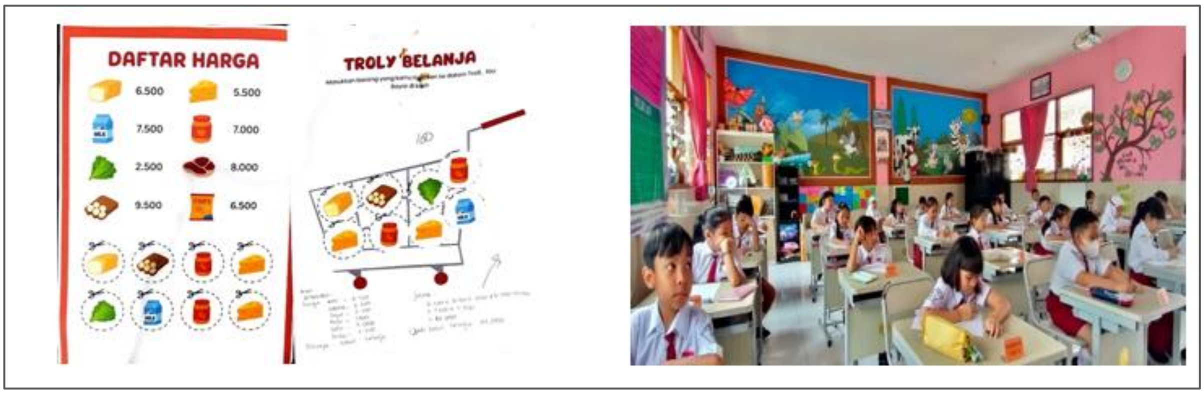

Figure 2. (A) Price list and shopping-cart media used in contextual tasks; (B) classroom implementation of buying-and-selling activities in fourth-grade mathematics learning.

Note: The provided illustration depicts the media context and the authentic classroom environment in which the problem-solving activities took place.

DISCUSSION

The findings of this study indicate that contextual problem-solving instruction improved students' performance on whole-number tasks and, more importantly, transformed how mathematical meaning was constructed in the classroom. The observed improvement should therefore be interpreted as a conceptual shift rather than merely a numerical increase in test scores. This shift can be explained by the role of contextual tasks in providing concrete referents that connect mathematical operations to meaningful situations. Through this connection, students were able to move beyond procedural imitation toward relational understanding. When students explained why addition was used to determine total prices and why subtraction was required to calculate change, this reflects a transition from rule-based execution to meaning-based reasoning. In this sense, the findings support the view that problem solving becomes pedagogically significant when it positions students as active constructors of meaning rather than passive followers of procedures.

This finding supports and extends Jäder and Johansson's (2025) argument that mathematical problem solving deepens conceptual understanding when students engage with representations to interpret relationships. While previous studies emphasize the use of representations, the present study shows that the critical factor lies in how students interpret and justify those representations. Students did not simply apply representations procedurally, but used them to explain the relationships between quantities and operations, indicating a higher level of cognitive engagement. At the same time, the findings support Ayari et al.'s (2025) conclusion that problem-based learning is most effective when grounded in authentic contexts. However, this study extends that perspective by demonstrating that, in an elementary whole-number context, authentic buying-and-selling situations function not only to increase engagement but also as an epistemic bridge. Through this bridge, abstract operations become meaningful, discussable, and transferable to everyday experiences. Thus, the contribution of this study lies in clarifying the mechanism by which contextual problem-solving facilitates conceptual construction.

The findings further indicate that contextuality plays a central, constitutive role in learning rather than functioning merely as an illustrative teaching aid. This can be explained by the way concrete media, such as play money and price lists, enable students to interpret numbers as functional tools embedded in purposeful activity. In contrast to abstract-symbolic instruction, contextualized learning situates numbers within goal-oriented actions, allowing students to connect operations, quantities, and purposes simultaneously. This finding is consistent with Yunitasari et al.'s (2023) report regarding improved learning outcomes and reduced mathematics anxiety, as well as Budiman et al.'s (2025) finding that contextual instruction supported by concrete media enhances motivation and conceptual understanding. However, the present study refines these findings by showing that context contributes not only to affective engagement but also directly to the construction of conceptual understanding. In this sense, context can be understood as part of the cognitive architecture of learning, because it structures how mathematical meaning is formed and connected.

Another important dimension concerns the social and affective aspects of learning. The increased confidence, participation, and willingness to revise thinking observed in this study can be explained by the collaborative structure of contextual problem-solving activities. These activities create opportunities for dialogue, negotiation, and reflection, through which students externalize and reorganize their thinking. This finding supports constructivist and sociocultural perspectives, which emphasize that knowledge is developed through interaction and participation. In line with previous studies, the results confirm that meaningful mathematics learning is shaped not only by cognitive demand but also by the quality of social interaction that supports reasoning and explanation. However, this study extends prior research by showing that such interaction becomes more productive when embedded in meaningful and familiar contexts, as these contexts provide a shared reference point that facilitates communication and mutual understanding among students.

At the same time, the findings reveal that the effectiveness of contextual problem-solving instruction is conditional rather than automatic. This can be explained by the increased cognitive and instructional demands inherent in contextual learning, where students must interpret situations, select strategies, and justify their reasoning simultaneously. The results align with previous studies, indicating that contextual and problem-based learning require more instructional time and careful classroom management. In particular, students with lower initial abilities needed scaffolding to identify relevant information and choose appropriate strategies, suggesting that independent meaning construction does not occur without guidance. Therefore, while the findings support existing research on the effectiveness of contextual and problem-based learning, they also refine it by emphasizing the importance of pedagogical conditions. The success of contextual problem-solving depends on the teacher's ability to design meaningful contexts, manage time effectively, structure interactions, and provide appropriate scaffolding. In this way, the study not only confirms prior theory but also clarifies the practical conditions under which the theory can be successfully implemented in elementary mathematics classrooms.

CONCLUSION

This study aimed to analyze contextual problem-solving instruction as a pedagogical space for constructing elementary students' mathematical conceptual understanding in whole-number learning. The findings show that integrating authentic buying-and-selling contexts, play money, discussion, and reflective problem-solving activities contributed not only to improved learning outcomes but also to a shift from procedural performance toward more meaningful conceptual understanding. The main contribution of this study is to demonstrate that contextual problem-solving instruction should be understood as a pedagogical space in which mathematical meaning is actively constructed through experience, interaction, and reflection. In practice, these findings imply that elementary mathematics teachers should design learning tasks that connect abstract concepts to students' everyday experiences and provide sufficient scaffolding for reasoning and explanation. However, this study is limited to one classroom context, one teacher, and one mathematical topic, which restricts the transferability of the findings to broader settings. Future research is therefore recommended to examine the implementation of contextual problem-solving instruction across different grade levels, mathematical topics, and school contexts, and to explore its relationship with other dimensions, such as mathematical reasoning, communication, and long-term conceptual retention.

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