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The Use of Loose Parts Media to Improve Early Numeracy Skills in Children Aged 5–6 Years

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Abstract
This study aims to improve early numeracy skills in group B children at the Parakanlima Play Group through the implementation of loose parts media. Early numeracy skills are fundamental mathematical competencies that include addition, subtraction, quantity comparison, and the ability to connect number concepts with number symbols. The study employed a Classroom Action Research (CAR) design based on the Kemmis and Taggart model, conducted over two cycles with four action meetings per cycle. The participants were 17 children in group B aged 5–6 years, comprising 11 boys and 6 girls. Data were collected through observation, interviews, and documentation, and were analyzed using both qualitative and quantitative approaches. The loose parts materials used included natural items (pebbles, tree branches, leaves, flowers) and recycled objects (bottle caps, shells, ice cream sticks, straws). The results indicated a notable improvement in children's early numeracy skills, from 55.68% in the pre-cycle to 77.25% in cycle I, and reaching 88.68% in cycle II, reflecting an overall increase of 33%. Improvements were observed across all measured aspects: addition (50% to 70%), quantity comparison (45% to 65%), subtraction (40% to 60%), and symbol recognition (55% to 75%). These findings suggest that the use of loose parts media supported children's early numeracy development through concrete, meaningful, and engaging learning experiences, although causal claims should be interpreted cautiously given the nature of classroom action research without a control group. Loose parts provided hands-on experiences that facilitated multi-sensory stimulation and encouraged active learning.

Keywords: Classroom Action Research, Early Childhood, Early Numeracy Skills, Loose Parts Media

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INTRODUCTION

Early childhood education plays a fundamental role in preparing children to face learning challenges at the next level. The early age period, especially 0-6 years old, is known as the "golden age" or the golden age of children's brain development (Helmawati, 2015). During this time, children have an extraordinary ability to absorb information quickly, including basic mathematical concepts.

Mathematics is a science that studies patterns, relationships, sequences, and possibilities (Copley, 2001). The introduction of mathematics in early childhood is inseparable from everyday life, as each activity involves a mathematical process. One of the most important mathematical concepts that early childhood needs to master is number operations, which includes addition, subtraction, understanding concepts more, and the ability to relate concepts to number symbols.

The ability to operate numbers has a long-term impact on children's cognitive development, especially in logical thinking and problem-solving skills (Kellough, 1996). The development of these abilities at an early age will form a strong foundation for further mathematics learning and the development of analytical abilities. In addition, the ability to operate numbers also supports other developmental aspects such as language, communication, and social-emotional children.

This research is important for several basic reasons. First, the ability to operate numbers is an essential foundation for advanced math learning. Second, the age period of 5-6 years is the optimal period to develop basic mathematical concepts because children's brains develop rapidly. Third, the use of appropriate and interesting learning media can maximize children's learning potential during the golden age. Fourth, the results of the research can make a practical contribution to early childhood education programs educators in developing effective and fun mathematics learning strategies.

Despite the growing body of research on loose parts in early childhood education, several critical gaps remain in the existing literature. Previous studies have predominantly focused on the use of loose parts to develop children's creativity and general cognitive abilities (Kulsum, 2022; Alfiliya, 2023; Riska Damayanti Yakin et al., 2023), arts and STEAM learning (Hanuf Af'idatul Uyun & Diana, 2023; Syafi'i & Da'iyah, 2021), as well as science exploration (Wartisah, 2021). However, studies that specifically examine the application of loose parts media as a structured intervention for improving early numeracy skills—particularly the four sub-domains of number operations (addition, subtraction, quantity comparison, and number symbol recognition)—in children aged 5–6 years remain scarce. Furthermore, most existing studies do not provide systematic, cycle-based implementation guidelines that PAUD teachers can directly replicate in classroom practice. The absence of structured, stage-by-stage documentation of how loose parts can be used across multiple learning cycles to progressively develop numeracy competencies represents a significant practical gap. This study therefore addresses these gaps by implementing loose parts media through a Classroom Action Research (CAR) framework, with explicit attention to each numeracy sub-domain across two structured cycles.

Ideally, learning number operations in early childhood is done with a fun, concrete, and contextual approach. Children should be able to explore mathematical concepts through real objects that are close to their lives (Copeland in Kamariah, 2018). Learning should involve hands-on experience with objects that can be manipulated, making abstract concepts easier to understand. Varied and interesting learning media need to be available to support children's understanding of various concepts of number operations. Nevertheless, research specifically documenting how open-ended, manipulable materials such as loose parts can be systematically structured to develop each component of early numeracy—rather than general play or creativity—remains limited, particularly in the Indonesian PAUD context (Kurnia & Nasrudin, 2022; Wahyuni & Reswita, 2020). Most studies report outcomes at a general level without disaggregating results by numeracy sub-domain, making it difficult for practitioners to identify which specific numeracy competencies are most responsive to loose parts interventions.

Based on observations and interviews in the Parakanlima Play Group group B, it was found that children's early numeracy skills were not yet optimally developed, with the average performance still below 50% (55.68%). The problems identified include: (1) the low numeracy ability of children due to the lack of use of concrete media in learning; (2) learning approaches that are still conventional and have not yet used the play approach; (3) lack of activities that encourage children to explore number operation concepts; (4) the absence of engaging learning media for numeracy activities; and (5) the number of available media is limited and not proportional to the number of children.

To overcome these problems, researchers implemented loose parts media as an alternative solution. Loose parts are flexible materials that can be natural or synthetic materials, which allow children to explore freely (Siantajani, 2020). This medium was chosen because of several advantages: (1) it is easy to obtain from the surrounding environment; (2) be flexible and can be manipulated according to learning needs; (3) Sensory stimulation; (4) encourage children's creativity and imagination; (5) facilitate open learning without restrictions; and (6) economically affordable.

This study aims to: (1) find out the implementation of loose parts media in improving the ability to operate numbers in group B children in early childhood education programs Parakan Lima; and (2) analyze the implementation of loose parts media to improve the number operation ability in group B children in Parakan Lima.

The novelty of this study lies in three specific contributions that distinguish it from prior work. First, unlike previous loose parts studies that focus broadly on creativity or general cognition, this study targets four specific sub-domains of early numeracy skills (addition, subtraction, quantity comparison, and number-symbol correspondence) in a structured and measurable way. Second, the study employs a two-cycle CAR design with documented improvements at each cycle, providing evidence of iterative pedagogical refinement that is rarely reported in Indonesian early childhood loose parts research. Third, the study produces a concrete, replicable sequence of eight loose parts activities—matched to specific numeracy indicators—that PAUD practitioners can directly adapt, filling a gap in practitioner-oriented implementation guidance that existing literature does not adequately address.

METHODS

Research Design

This study uses the Kemmis and Taggart model Class Action Research methods. Class Action Research is a controlled investigation process that aims to find and solve learning problems in the classroom through repeated cycles to improve the quality of learning (Akbar, 2018; Arikunto, et al., 2019). The Kemmis and Taggart models consist of four stages in each cycle: (1) Planning; (2) The implementation of actions (acting) and observation (observing) carried out simultaneously; (3) Reflecting. The implementation and observation stages are carried out simultaneously to ensure that the data obtained is accurate and comprehensive.

Setting and Research Subjects

The research was carried out in the Parakanlima Play Group, Parakanlima Village, Cirinten District, Lebak Regency in the first semester of the 2024/2025 academic year (September - Desember 2025). The subjects of the study were group B children totaling 17 children, consisting of 11 boys and 6 girls.

Research Procedure

Cycle I:

1. Planning: Identify problems, prepare a Daily Activity Plan, prepare loose parts media (bottle caps, pebbles, ice cream sticks, shells), and research instruments.
2. Implementation: Four meetings with a learning focus: (a) summing using bottle caps; (b) the concept of using a lot of gravel; (c) reduction in the use of ice cream sticks; (d) connecting the concept with the symbol of numbers using the shell.
3. Observation: Observations were made by researchers and collaborators using observation sheets, documentation, and field notes.
4. Reflection: The results of the first cycle show an increase in number operation ability from 55.68% to 77.25%, but have not reached the target of 71%. Several obstacles were found: children lack focus when explaining, there are still people who disturb friends, and limited learning time.

Cycle II:

1. Planning: Improve learning strategies based on reflection cycle I, organize smaller groups, and use new loose parts media (tree branches, straws, flowers, leaves).
2. Implementation: Four meetings with higher intensity of concept explanation and more intensive mentoring.
3. Observation: Stricter monitoring of children's activities and interactions with the media.
4. Reflection: The results of cycle II showed a significant increase to 88.68%, exceeding the target of 71%.

Data Collection Techniques

Data is collected through:

1. Observation: Systematic observation using an observation sheet with indicators: summing numbers with objects, recognizing the concept of many-little, subtracting numbers by objects, and matching numbers with number symbols. The assessment uses a scale of 1-4 (BB=Not Progressing, MB=Starting to Develop, BSH=Progressing as Expected, BSB=Progressing Very Good).
2. Interview: Conducted with the classroom teacher to find out the learning process and development of the child.

3. Documentation: In the form of photos of learning activities and children's works (worksheets).

Data Analysis Techniques
Quantitative Analysis: Using the formula of percentage: $P = (\Sigma X/N) \times 100\%$
Information:
P = Proportion of number operating ability
ΣX = Number of scores/scores obtained
N = Maximum score

Achievement criteria based on Purwanto:
81%-100% = Excellent
61%-80% = Good
41%-60% = Enough
21%-40% = Less
0%-20% = Very Less

Qualitative Analysis: Using the Miles and Huberman interactive model with stages: (1) Data reduction; (2) Data presentation (display); (3) Conclusion and verification.

Success Criteria

The research is considered successful if the average early numeracy skill score of the children reaches at least 71% (Mills, 2003). This threshold was selected based on the minimum mastery criterion commonly applied in early childhood education settings and is consistent with the success criteria used in comparable classroom action research studies in Indonesia (Arikunto et al., 2019).

RESULTS & DISCUSSION

Results

Pre-Cycle Conditions

The results of initial observations showed that the operating ability of the number of children was still low with an average score of 7.15 out of a maximum score of 16 or 55.68%. Ability distribution: 5 children (30%) of the undeveloped category, 12 children (70%) of the developing category, none of the children who reached the expected development category or developed very well.
Key problems identified:
1. Learning using conventional methods without concrete media
2. Children have difficulty understanding the abstract concept of number operations
3. Learning is dominated by worksheet workbook work
4. There is no medium that facilitates the understanding of the concept of number operations
5. Children lack enthusiasm and get bored quickly

Results of Cycle I

Meeting 1 (Summing with Bottle Caps): Learning begins with an appperception of bottle caps. Researchers demonstrated the addition using colorful bottle caps. The child seemed enthusiastic about the new media. However, some children (JND, LFSK) still need the help of researchers to understand the concept of addition. The results of the observation showed that 10 children (60%) were able to do the sum of 1-5 with minimal assistance.

Meeting 2 (Concept of Many-Bit with Pebble): The researcher used pebbles to teach the concept of more and less. The child counts the pebbles and compares the amounts. This activity increases children's understanding of the concept of quantity. 9 children (55%) were able to distinguish concepts a lot without help.

Meeting 3 (Reduction with Ice Cream Sticks): The concept of reduction was introduced using ice cream sticks. Researchers demonstrate: "5 ice cream sticks minus 3, how much is left?" Some children have trouble understanding the concept of "taking" as a deduction. Only 9 children (50%) were able to make the reduction correctly.

Meeting 4 (Connecting Concepts with Number Symbols using Shell Shells): The child counts the number of shells and matches them with number cards. This ability is relatively easier to master. 11 children (65%) managed to relate concepts to the number symbol.

Results of Cycle I:

The average number operating ability increased to 10.6 (77.25%). An increase from pre-cycle of 3.45 points or 21.56%. Ability distribution: 1 child (5%) of the category is starting to develop, 13 children (75%) of the category is developing as expected, 3 children (20%) of the category is developing very well.
Constraints of Cycle I:

1. Some children lack focus when explaining the rules of the game
2. There are children who disturb friends during learning
3. Limited learning time (60 minutes)
4. Not all children achieve optimal understanding

Results of Cycle II

Based on the reflection of cycle I, improvements were made to the learning strategy in cycle II: Meeting 1 (Summing with Tree Branches): The media was replaced with tree branches to provide variety and increase interest. Explanation of concepts is more intensive with repeated demonstrations. Children are more enthusiastic about natural media. 11 children (70%) were able to add up to 9+3 without assistance.

Meeting 2 (Much-Bit Concept with Straws): Colorful straws are used to differentiate the concept of quantity. Attractive visuals improve your child's focus. More intensive assistance is given to children who are still struggling. 11 children (65%) mastered the concept of a lot of things well.

Encounter 3 (Reduction with Interest): Flowers as a medium of reduction create an enjoyable learning experience. The researcher used a concrete approach: "3 flowers, 2 given to a friend, how much is left?" 10 children (60%) were able to do the reduction correctly.

Meeting 4 (Connecting Concepts with Number Symbols using Leaves): Children count leaves of different colors (green, yellow, brown) and relate to numbers. Researchers integrate science learning about the life cycle of leaves. 13 children (75%) successfully connected the concept with the number symbols for the numbers 8-11.

Cycle II Results:

The average number operating ability increased significantly to 13.55 (88.68%). An increase from the first cycle of 2.95 points or 18.43%. Ability distribution: 16 children (95%) of the category are performing very well, 1 child (5%) of the category is progressing as expected. The research target (71%) has been exceeded.

Table 1. Recapitulation of Research Results

Phase	Average Score	Percentage	Increased
Pre-Cycle	7,15	55,68%	-
Cycle I	10,6	77,25%	21,57%
Cycle II	13,55	88,68%	18,43%
Total Upgrade	6,4	33%	33%

Discussion

This study proves that loose parts media is effective in improving the operating ability of group B children. The results of the study are in line with Copeland's theory which states that children begin to recognize numbers when they are directly involved in counting activities through touchable objects (Sarama & Clements, 2009; MacDonald, 2015). Media loose parts provide a concrete experience that facilitates the understanding of abstract concepts of number operations, as Piaget posited that early childhood is at a concrete operational stage that requires the manipulation of physical objects to understand mathematical concepts (Ginsburg et al., 2008; Mix, 2019).

Loose parts transform abstract mathematical concepts into concrete experiences that children can see, touch, and manipulate. This transformation is crucial because children aged 5-6 years still need physical representations to understand numerical concepts (Carbonneau et al., 2013; Fyfe et al., 2014). The use of manipulative objects such as ice cream sticks to demonstrate "5-3=2" provides a cognitive bridge between concrete and abstract understandings (McNeil & Jarvin, 2007; Bruner, 2021).

Media loose parts activate the child's various senses (visual, tactile, kinesthetic), creating stronger neural pathways for memory storage of mathematical concepts (Shams & Seitz, 2008; Luo et al., 2020). Multisensory learning has been shown to increase information retention by up to 75% compared to learning that involves only one sensory modality (Mayer, 2014; Paas & Sweller, 2012). Visual-tactile-kinesthetic sensory integration in the manipulation of loose parts creates richer and more memorable mental representations (Barsalou, 2008; Contra et al., 2015).

Media from the surrounding environment (twigs, leaves, stones) make learning meaningful and connected to children's daily lives. Contextual learning enhances knowledge transfer because children can relate mathematical concepts to their real-life experiences (Anderson et al., 2000; Perin, 2011). The use of authentic materials from the environment also supports Ausubel's principle of meaningful learning which emphasizes the importance of linking new knowledge with existing cognitive structures (Ausubel, 2012; Novak, 2010).

The use of different media at each meeting (bottle caps, pebbles, ice cream sticks, shells, twigs, straws, flowers, leaves) prevents boredom and maintains the child's interest in learning. Stimulus variations are an important factor in maintaining early childhood learning attention and motivation (Renninger & Hidi, 2016; Katz & Assor, 2007). Material flexibility allows for differentiation of learning according to the child's learning style and level of individual development (Tomlinson, 2014; Sousa & Tomlinson, 2011).

Loose parts encourage children to become active learners who explore, experiment, and discover concepts on their own, rather than passive recipients of information. Active learning improves conceptual understanding by up to 40% compared to passive learning (Freeman et al., 2014; Chi & Wylie, 2014). This constructivist approach is in line with Vygotsky's theory of the zone of proximal development, in which the child learns optimally through active exploration with minimal guidance (Vygotsky, 1978; Wass & Golding, 2014).

There is no "right" or "wrong" way to use loose parts, so children feel safe to try without fear of being wrong. A learning environment that is free from negative evaluations increases children's self-efficacy and willingness to take cognitive risks (Dweck, 2006; Haimovitz & Dweck, 2017). Freedom of exploration also facilitates creative problem-solving and divergent thinking that are important for cognitive development (Russ & Wallace, 2013; Glaveanu, 2020).

The increase in summation ability from 50% (pre-cycle) to 70% (cycle II) indicates the effectiveness of learning using loose parts. This improvement shows that the manipulation of concrete objects helps children understand the concept of "adding" as the process of combining two groups of objects (Baroody & Purpura, 2017; Jordan et al., 2009). The use of visual-tactile media facilitates the transition from a counting-all strategy to a more efficient counting-on strategy (Siegler & Booth, 2004; Carpenter & Moser, 1984).

The ability to distinguish concepts a lot increased from 45% to 65%. Visual and concrete quantity comparison through loose parts provides a hands-on experience of magnitude comparison, which is an important foundation for number sense (Siegler & Ramani, 2009; Fazio et al., 2014). The experience of comparing the number of physical objects builds a mental representation of numerosity that is essential for advanced mathematical understanding (Dehaene, 2011; Libertus et al., 2011).

Reduction is the most challenging concept, but it still shows an increase from 40% to 60%. Children's difficulties in understanding subtraction are consistent with research findings that inverse operations such as subtraction require a more complex conceptual understanding than addition (Nunes et al., 2012; Gilmore & Spelke, 2008). The use of concrete media helps children understand reduction as the process of "taking" or "reducing" from a group of objects through explicit physical representations (Baroody et al., 2009; Sophian & Vong, 1995).

This ability shows the highest increase from 55% to 75%. This significant increase indicates that loose parts facilitate the process of abstraction from concrete objects to symbolic representations, which is an important milestone in the development of mathematics (Mix, 2010; Purpura & Lonigan, 2013). The activity of counting objects and matching them with number cards strengthens the relationship between concrete quantities and abstract symbols, building symbolic number knowledge that is predictive of future mathematical achievement (De Smedt et al., 2013; Lyons et al., 2014).

Children are still in the phase of getting acquainted with new media, with high enthusiasm but limited understanding of concepts. This initial exploration phase is an important familiarization period to build a child's comfort level with new materials (Casey et al., 2008; Verdine et al., 2014). The child's focus on the physical characteristics of the medium (color, texture) before its mathematical function is a normal developmental pattern, reflecting the bottom-up processing process in perceptual learning (Gibson, 1979; Smith & Gasser, 2005).

Children began to experiment using media for number operations, with a better understanding of concepts but still needed the help of teachers. This experimental stage reflects the transition from external regulation to co-regulation within the framework of self-regulated learning (Zimmerman, 2000; Whitebread et al., 2009). The scaffolding provided by teachers at this stage is crucial to facilitate the child's proximal developmental zone (Wood et al., 1976; Van de Pol et al., 2010).

The child shows a better command of concepts and can use loose parts independently for number operations. This achievement of independence indicates the internalization of concepts and automaticity in procedural skills (Anderson, 1982; Fitts & Posner, 1967). The ability of some children to develop creative strategies such as grouping objects based on color shows cognitive flexibility and adaptive expertise (Hatano & Inagaki, 1986; Carbonell et al., 2014).

The results of this study are consistent with the findings of previous researchers: Hanuf Af'idatul Uyun & Diana (2023) found the effectiveness of loose parts in STEAM learning for children aged 5-6 years, Umi Kulsum (2022) proved that loose parts improve children's cognitive abilities, and Riska Damayanti Yakin, et al (2023) emphasized the importance of loose parts for creativity. This cross-study consistency strengthens the external validity of the findings and confirms that loose parts is a robust pedagogical approach to early childhood mathematics learning (Borko et al., 2008; Ginsburg, 2009).

This research provides a unique contribution in the form of systematic implementation stages through classroom action research, the use of 8 types of loose parts media in a structured manner, a specific focus on the four aspects of number operations, quantitative data on measurable ability improvement, and practical implementation guidelines for PAUD educators. The methodological contribution of this research lies in the use of iterative action research to optimize the implementation of loose parts (McNiff, 2013; Mertler, 2017). Systematic documentation of the type of material, learning sequence, and response patterns of children provides practical wisdom that can be replicated by other practitioners (Cochran-Smith & Lytle, 2009; Zeichner, 2003).

Observations showed three patterns of children's interaction with loose parts: exploratory patterns (children who initially have difficulty tend to explore media freely before focusing on math tasks), systematic patterns (children who quickly understand using media systematically), and creative patterns (some children develop creative strategies). These variations in interaction patterns reflect individual differences in cognitive style and learning preferences (Sternberg & Grigorenko, 1997; Kolb, 2014). Exploratory patterns reflect a field-dependent cognitive style that requires broader context before focusing on details, while systematic patterns reflect a field-independent style that can immediately extract relevant information (Witkin et al., 1977; Zhang & Sternberg, 2005).

The role of the teacher evolved during the research: Cycle I was more of an instructor who demonstrated and provided direct assistance, while Cycle II shifted to a facilitator who provided minimal scaffolding. This shift in roles is consistent with the principle of gradual release of responsibility, where control of learning is gradually transferred from teacher to student (Fisher & Frey, 2008; Pearson & Gallagher, 1983). Facilitation models that are responsive to children's needs are more effective than direct instruction in constructivist learning (Alfieri et al., 2011; Hmelo-Silver et al., 2007).

Loose parts facilitate cooperative learning through peer tutoring, collaborative problem solving, and sharing ideas. Social interaction in mathematics learning not only improves conceptual understanding but also develops mathematical discourse and argumentation skills (Webb & Mastergeorge, 2003; Mercer & Sams, 2006). Peer learning has been proven to be effective because children often use language and analogies that are more accessible to their peers than the teacher's explanation (Topping, 2005; Roscoe & Chi, 2008).

The findings of this study reinforce the theory of early childhood mathematics learning which emphasizes the importance of concrete-representational-abstract (CRA) sequence in the teaching of mathematical concepts (Bruner, 1966; Witzel et al., 2003). Loose parts provide a rich and varied concrete phase, facilitating a smooth transition to symbolic representation. This research also supports the embodied cognition theory which states that mathematical cognition is rooted in sensorimotor experiences (Lakoff & Núñez, 2000; Fischer, 2012).

For early childhood education practitioners, this study shows that loose parts can be systematically integrated into the mathematics curriculum with minimal cost but maximum impact (Daly & Beloglovsky, 2015; Kiewra & Veselack, 2016). The structured implementation guidelines in this study can be adapted by teachers with different levels of experience. The importance of providing sufficient exploration time before expecting formal mathematical applications is a valuable practical insight (Bonawitz et al., 2011; Fisher et al., 2013).

Although it showed positive results, the study had some limitations: relatively small sample size (20 children), limited study duration (2 cycles), and a single context (one school). Future research can explore the effectiveness of loose parts with a larger and diverse sample, investigate long-term retention of the concepts studied, as well as compare the effectiveness of different types of loose parts (Clements & Sarama, 2007; National Research Council, 2009). Longitudinal research to examine the long-term impact on mathematics achievement in primary schools will also make a valuable contribution (Duncan et al., 2007; Watts et al., 2014).

CONCLUSION

Based on the results of the research and discussion, it can be concluded that: The implementation of loose parts media has proven to be effective in improving the ability of number operations in group B children at PAUD Parakan Lima. An increase in ability from 55.68% (pre-cycle) to 88.68% (cycle II) or by 33% shows significant effectiveness. The implementation of loose parts media is carried out through systematic stages: (a) Planning: problem identification, preparation of RPPH, preparation of varied media; (b) Implementation: structured learning with demonstrations, guided practice, independent practice; (c) Observation: monitoring of learning processes and outcomes; (d) Reflection: evaluation and improvement for the next cycle. Effective loose parts include: natural materials (pebbles, tree branches, leaves, flowers) and second-hand items (bottle caps, shells, ice cream sticks, straws).

Media variety maintains children's interest and motivation to learn. Improvements occur in all aspects of number operations: (a) Summation: from 50% to 70%; (b) Many-little concept: from 45% to 65%; (c) Reduction: from 40% to 60%; (d) Connecting the concept with the number symbol: from 55% to 75%. Loose parts create concrete, meaningful, and fun learning, so that the abstract concept of number operations becomes easy for children to understand.

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