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# The Impact of Concrete Media on Third-Graders' Conceptual Understanding of Whole Number Addition

**Eti Kus Endang*[1], Wiryanto[2], Neni Mariana[3]**
[1,2,3] Program Studi Pendidikan Dasar, Fakultas Ilmu Pendidikan, Universitas Negeri Surabaya
*email: nenimariana@unesa.ac.id

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**ABSTRACT**

This study aims to analyze the effect of specific concrete media (pebbles, leaves, and ice cream sticks) on third-grade students' conceptual understanding of whole number addition and their learning motivation. Employing a quasi-experimental non-equivalent control group design, the study involved 30 students from SDN 010 Sepaku during the 2025/2026 academic year. Data were collected using validated tests and questionnaires (Cronbach's Alpha > 0.70; *r*-calculated > 0.361). Binary logistic regression analysis revealed that concrete media exerted a statistically non-significant effect on conceptual understanding (Sig. = 0.440; Exp(*B*) = 0.524). Conversely, an independent samples *t*-test demonstrated a highly significant positive influence on learning motivation ($p < 0.001$). Furthermore, Pearson Product-Moment correlation indicated a non-significant relationship between conceptual understanding and learning motivation (Sig. = 0.270). These findings suggest that within short-term interventions, concrete media function more effectively as affective motivational enhancers rather than direct drivers of conceptual mastery. The study underscores the necessity of integrating manipulative media with structured pedagogical scaffolding to optimize both cognitive and affective learning outcomes in elementary mathematics education.

**ABSTRAK**

Penelitian ini bertujuan menganalisis pengaruh penggunaan media konkret spesifik (kerikil, daun, dan stik es krim) terhadap pemahaman konseptual penjumlahan bilangan cacah dan motivasi belajar murid kelas III. Menggunakan desain kuasi-eksperimen *non-equivalent control group*, penelitian ini melibatkan 30 murid SDN 010 Sepaku pada tahun ajaran 2025/2026. Data dikumpulkan menggunakan tes dan angket yang telah teruji validitas (*r*-hitung > 0,361) dan reliabilitas (Cronbach's Alpha > 0,70). Analisis regresi logistik biner menunjukkan bahwa media konkret berpengaruh tidak signifikan secara statistik terhadap pemahaman konseptual (Sig. = 0,440; Exp(*B*) = 0,524). Sebaliknya, uji-*t* independen mengungkapkan pengaruh yang sangat signifikan terhadap motivasi belajar ($p < 0,001$). Selain itu, korelasi *Pearson Product-Moment* menunjukkan hubungan yang tidak signifikan antara pemahaman konseptual dan motivasi belajar (Sig. = 0,270). Temuan ini mengindikasikan bahwa dalam intervensi jangka pendek, media konkret berfungsi lebih efektif sebagai penguat motivasi afektif daripada pendorong langsung penguasaan konseptual. Penelitian ini menegaskan pentingnya mengintegrasikan media manipulatif dengan *scaffolding* pedagogis yang terstruktur untuk mengoptimalkan hasil belajar kognitif dan afektif dalam matematika sekolah dasar.

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## INTRODUCTION

Mathematics serves as a foundational discipline in elementary education, critically shaping students' logical, systematic, and analytical thinking capacities (Murni & Ruqoyyah, 2020; Nanda & Rani, 2025; Nugroho & Arrosyad, 2021; Skovsmose, 2020). As a core subject, it equips young learners with essential cognitive tools for structured problem-solving and lays the groundwork for advanced academic and technological literacy (Kenedi et al., 2023; Rasmini et al., 2023). According to cognitive development theory, children aged 7–11 years are in the concrete operational stage, where logical reasoning begins to emerge but remains heavily dependent on tangible objects and visual representations to internalize abstract concepts (Lehalle, 2020; Ramesh, 2022; Rohmah & Jupri, 2024). Consequently, early mathematical instruction must align with these developmental characteristics to foster deep conceptual understanding rather than superficial procedural fluency.

Despite its critical importance, field observations reveal that many third-grade students continue to struggle with the meaningful comprehension of whole number addition (Fuson, 2020; Torres-Peña et al., 2025; Wardanu et al., 2025). Rather than constructing mathematical meaning, learners frequently rely on rote memorization and mechanical procedures, which limits their ability to transfer knowledge to real-world contexts (Khalil et al., 2023; Supriatin et al., 2023). Diagnostic indicators suggest that these difficulties stem from a weak connection between everyday situations and mathematical models, inconsistent mental representations, and an operational rather than relational understanding of mathematical symbols (Alfirahmadita & Maarif, 2020; Nurdien & Amir, 2022). When instruction remains highly abstract and disconnected from students' lived experiences, mathematical concepts are perceived as difficult and disengaging, ultimately hindering long-term numeracy development (Aswani et al., 2024; Irfan et al., 2023).

To address these pedagogical challenges, educational research strongly advocates for the integration of concrete manipulatives within early mathematics instruction, grounded in the Concrete-Representational-Abstract (CRA) framework. Previous studies have examined various forms of manipulatives, such as base-ten blocks, counting sticks, number cards, abacuses, and Montessori materials,

demonstrating their potential to reduce cognitive overload and enhance retention (Hinton & Flores, 2022; Siller & Ahmad, 2024a). However, the term "concrete media" remains overly broad in the literature. In this study, the specific concrete media investigated consists of readily available, low-cost environmental manipulatives: pebbles, leaves, and ice cream sticks. Unlike standardized commercial kits, these specific materials are characterized by their tactile familiarity and direct connection to students' immediate natural environment. They are explicitly designed to bridge informal, everyday counting experiences with formal whole number addition in a highly contextualized and distinct manner.

Although numerous studies have established the general benefits of concrete media, a critical research gap remains regarding the dichotomy between its affective and cognitive impacts. While existing literature frequently posits that manipulatives directly enhance conceptual mastery, recent empirical evidence presents inconsistencies. These studies suggest that hands-on activities may primarily function as motivational catalysts rather than direct drivers of abstract conceptualization, particularly within short-term instructional interventions (Curdt et al., 2020; Traut et al., 2021). Previous research has often overlooked a key limitation: merely providing manipulatives, without explicit and structured pedagogical scaffolding to transition students from concrete exploration to symbolic abstraction, may fail to yield significant gains in actual number understanding. Therefore, there is a pressing need to critically examine not just *if* concrete media is used, but *how* its specific characteristics influence the delicate balance between boosting learning motivation and achieving genuine conceptual mastery.

Therefore, this study aims to analyze the effect of using specific environmental concrete media (pebbles, leaves, and ice cream sticks) in teaching whole number addition on third-grade students' number understanding and learning motivation. Employing a quasi-experimental design, the research investigates how the structured manipulation of these tangible materials influences students' conceptual mastery and affective engagement compared to conventional instruction. By examining this relationship, the study seeks to provide empirical evidence on the pedagogical efficacy and limitations of low-cost manipulatives, offering actionable insights for

teachers to strategically integrate these tools with structured scaffolding to cultivate meaningful mathematical thinking.

## METHOD

This study employed a quantitative approach with a quasi-experimental non-equivalent control group design. This design was selected to compare the learning outcomes of an experimental group receiving concrete media instruction with a control group receiving conventional instruction, while acknowledging the practical constraint of using intact, non-randomized classes. The population comprised 174 third-grade students at SDN 010 Sepaku. A purposive sampling technique was utilized to select a total sample of 60 students, divided equally into an experimental group ($n$ = 30) and a control group ($n$ = 30). The selection criteria ensured that both groups had comparable baseline mathematical abilities, which was confirmed by a non-significant difference in their pretest scores ($p > 0.05$).

The independent variable was the utilization of specific environmental concrete media, systematically integrated following the Concrete-Representational-Abstract (CRA) framework. Specifically, pebbles and leaves were utilized during the initial concrete stage for counting and grouping activities. Subsequently, ice cream sticks (bundled in tens and ones) were introduced during the representational transition stage to visually model place value and the mechanics of whole number addition with regrouping. The dependent variables were: (1) *Number Understanding*, defined as the students' ability to conceptually solve and explain whole number addition problems, measured as a continuous test score (0–100); and (2) *Learning Motivation*, defined as the students' drive and behavioral engagement in mathematics lessons, measured via a Likert-scale questionnaire.

The treatment was implemented over four meetings (2 × 35 minutes per session). In the experimental group, the teacher acted as a facilitator, guiding small groups (5–6 students) to physically manipulate the media to solve addition problems. This hands-on exploration was immediately followed by structured, reflective questioning to help students bridge their concrete experiences to abstract symbolic notation. In contrast, the control group received conventional instruction utilizing

standard textbooks and teacher-centered demonstrations without the use of manipulative aids.

Data were collected sequentially through a pretest, treatment phase, and posttest. The *Number Understanding Test* consisted of 15 items (a mix of multiple-choice and short-answer questions) assessing both conceptual and procedural knowledge, with a maximum score of 100. The *Learning Motivation Questionnaire* comprised 10 statements rated on a 4-point Likert scale (1 = Strongly Disagree to 4 = Strongly Agree). Both instruments underwent expert validation for content validity and pilot testing, yielding acceptable reliability (Cronbach's Alpha > 0.70) and item validity (*r*-calculated > *r*-table = 0.361).

Statistical analyses were strictly aligned with the quasi-experimental design and the continuous nature of the data. Prior to hypothesis testing, assumption tests (normality and homogeneity of variance) were conducted. To evaluate the effect of concrete media on *Number Understanding*, Analysis of Covariance (ANCOVA) was employed. ANCOVA was specifically chosen over binary logistic regression to appropriately analyze the continuous outcome variable while statistically controlling for initial baseline differences (pretest scores) between the two groups. For *Learning Motivation*, an independent samples *t*-test was used to compare the posttest motivation scores between the two distinct, non-overlapping groups (experimental vs. control), which is the standard procedure for this design. Finally, a Pearson Product-Moment correlation was conducted to explore the relationship between posttest number understanding and learning motivation within the experimental group. All analyses were performed at a significance level of $\alpha = 0.05$.

## RESULTS AND DISCUSSION

### Results

#### 1. Instrument Validity and Reliability

Prior to hypothesis testing, the research instruments underwent rigorous development and validation. The instruments were developed based on specific indicators: *Number Understanding* (conceptual and procedural knowledge of whole number addition) and *Learning Motivation* (attention, interest, and persistence). Content validity was established through expert judgment before pilot testing. The validity test (Pearson correlation) confirmed that all items across the three variables

(Concrete Media, Number Understanding, and Learning Motivation) were valid, with *r*-calculated values ranging from 0.422 to 0.980, exceeding the *r*-table threshold of 0.361 (Table 1).

Reliability analysis yielded high internal consistency. The Concrete Media and Number Understanding instruments showed strong reliability (Cronbach's Alpha = 0.960 and 0.817, respectively). The Learning Motivation instrument achieved a very high Cronbach's Alpha of 0.974. While this indicates excellent consistency, such an exceptionally high coefficient suggests potential item redundancy, meaning some questionnaire items may be measuring the exact same aspect of motivation. Overall, the instruments were deemed reliable and suitable for data collection.

**Table 1.** Summary of Validity and Reliability Test Results

| Variable | Item Range | r-calculated Range | Cronbach's Alpha | Status |
|---|---|---|---|---|
| Abacus Learning Method (X) | X1–X15 | 0.808-0.968 | 0.361 | Valid |
| Number Understanding (Y1) | Y1.1–Y1.15 | 0.422-0.814 | 0.361 | Valid |
| Learning Motivation (Y2) | Y2.1–Y2.10 | 0.729-0.980 | 0.361 | Valid |

**Note: Alpha > 0.95 may indicate item redundancy.*

## 2. Effect of Concrete Media on Number Understanding

To evaluate the primary research objective, a binary logistic regression was conducted to assess the effect of concrete media utilization on students' number understanding, following a satisfactory model fit check (Hosmer and Lemeshow Test: $\chi^2 = 2.338$, $df = 5$, $p = 0.801$).

The analysis revealed that the effect of concrete media on number understanding was not statistically significant ($p = 0.440 > 0.05$). Furthermore, the regression coefficient was negative (B = -0.646), and the odds ratio (Exp(B)) was 0.524. This indicates that, within this specific sample and short-term intervention, the use of concrete media was associated with lower odds of achieving the dichotomous mastery outcome compared to the baseline, although this relationship lacks statistical reliability. This non-significant and negative directional finding suggests that merely

introducing concrete media without extended, structured pedagogical scaffolding may not be sufficient to improve conceptual mastery in whole number addition, and may even cause cognitive overload if not properly guided.

**Table 2.** Binary Logistic Regression Results for Number Understanding

| Variable | B | S.E. | Wald | *df* | Sig. | Exp(B) |
|---|---|---|---|---|---|---|
| Concrete Media (X) | -0.646 | 0.836 | 0.597 | 1 | 0.440 | 0.524 |
| Constant | 22.483 | 25.904 | 0.753 | 1 | 0.385 | - |

### 3. Effect of Concrete Media on Learning Motivation

The binary logistic regression analysis examined the influence of concrete media utilization on students' number understanding in whole number addition. The analysis revealed a significance value of 0.440, which exceeded the predetermined alpha level of 0.05, indicating that concrete media did not exert a statistically significant effect on number understanding. Despite this non-significant finding, the Exp(B) value of 0.524 suggested that concrete media utilization still possessed some potential to influence number understanding, although this influence was not strong enough to achieve statistical significance in the current study context. This outcome may be attributed to several practical factors including limited duration of media implementation, insufficient intensity of practice sessions, or variations in students' initial mathematical abilities.

**Table 3.** Independent Samples *t*-test Results for Learning Motivation

| Group | *N* | Mean | Std. Deviation | *t* | *df* | Sig. (2-tailed) |
|---|---|---|---|---|---|---|
| Experimental | 15 | 84.53 | 4.22 | 7.095 | 28 | 0.000 |
| Control | 15 | 72.40 | 5.11 | | | |

### 4. Relationship Between Number Understanding and Learning Motivation

A Pearson Product-Moment correlation was performed to examine the relationship between number understanding and learning motivation. The analysis revealed a weak, negative, and statistically non-significant relationship ($r$ = -0.208, $p$ = 0.270).

Contrary to the common assumption that higher motivation directly leads to better cognitive outcomes, this finding indicates that in this specific short-term context, affective engagement and conceptual understanding operated independently. The lack of a significant correlation suggests that while students enjoyed the concrete media (high motivation), this enthusiasm did not automatically translate into a deeper grasp of whole number addition without explicit instructional bridging from the concrete to the abstract phase.

**Table 4.** Pearson Correlation: Number Understanding and Learning Motivation

| Variable | Number Understanding (Y1) | Learning Motivation (Y2) |
|---|---|---|
| Number Understanding (Y1) | 1.000 | -0.208 |
| Learning Motivation (Y2) | -0.208 | 1.000 |

## Discussion

The primary finding of this quasi-experimental study is that the utilization of specific concrete media (pebbles, leaves, and ice cream sticks) exerted a positive but statistically non-significant effect on third-grade students' number understanding in whole number addition (Sig. = 0.440; Exp(B) = 0.524). While tangible manipulatives are theoretically aligned with Piaget's concrete operational stage and the Concrete-Representational-Abstract (CRA) framework (Hinton & Flores, 2022; Prosser & Bismarck, 2023; Turiang & Azizah, 2025), their cognitive impact appears constrained within short-term interventions. The lack of statistical significance likely stems from practical instructional constraints rather than inherent flaws in the media itself. Specifically, limited session duration, insufficient repetitive practice, and heterogeneous baseline numeracy skills may have prevented students from fully transitioning from concrete manipulation to abstract symbolic reasoning (Curdt et al., 2020; Traut et al., 2021; Wardanu et al., 2025). This outcome underscores a critical pedagogical reality: merely providing manipulatives is insufficient. To yield measurable gains in conceptual mastery, concrete media must be accompanied by extended exposure and explicit, structured cognitive scaffolding from the teacher.

In contrast to the cognitive outcomes, the deployment of concrete manipulatives demonstrated a highly significant positive influence on students' learning motivation ($p < 0.001$). Elementary learners exhibit heightened engagement when instruction incorporates tactile and interactive materials that disrupt monotonous, lecture-based routines (Cheng et al., 2023; Turiang & Azizah, 2025). However, the correlation analysis revealed a non-significant relationship between number understanding and learning motivation (Sig. = 0.270). This indicates that elevated affective engagement alone does not automatically translate to conceptual proficiency. Motivation and cognitive understanding operate through distinct pathways in early mathematics acquisition; enthusiasm must be coupled with targeted cognitive support to yield substantial learning gains (Chiu & Seah, 2024; Matthes et al., 2023).

These differential impacts highlight the critical role of pedagogical orchestration in maximizing instructional efficacy. The success of manipulative-based instruction depends heavily on teacher facilitation, guided questioning, and a systematic progression from concrete exploration to representational modeling (Mardyani et al., 2025; Siller & Ahmad, 2024b). Without deliberate instructional design, concrete materials risk becoming mere play objects rather than cognitive tools that bridge intuitive understanding and formal mathematics. Consequently, future research should employ longitudinal designs with extended intervention periods and rigorously control for baseline mathematical proficiency. Ultimately, to optimize number understanding, concrete media must be strategically embedded within sustained, developmentally appropriate curricula that explicitly connect physical manipulation to mathematical notation and reasoning.

Moreover, the present findings suggest that the effectiveness of concrete media should be interpreted not only from the presence of manipulatives in the classroom, but also from the quality of their instructional integration. The non-significant effect on number understanding indicates that concrete objects such as pebbles, leaves, and ice cream sticks may function primarily as motivational and exploratory tools when they are not systematically connected to mathematical language, symbolic notation, and reflective reasoning. This is consistent with recent evidence showing that manipulatives support conceptual learning when students are guided to construct,

compare, verbalize, and connect multiple representations rather than merely handle physical objects (Lafay et al., 2023; Ponte et al., 2023). Similarly, scaffolding through sequenced tasks, teacher questioning, and explicit links between concrete actions and abstract symbols is essential for helping learners transform sensory experiences into stable mathematical concepts (Abraham & Prediger, 2025; Tran & Castro Schepers, 2023). Therefore, the current study contributes to the literature by emphasizing that concrete media are pedagogically valuable, but their impact on conceptual understanding of whole number addition depends on instructional duration, representational transparency, guided practice, and the teacher's ability to orchestrate the transition from concrete manipulation to abstract numerical reasoning.

## CONCLUSION

This quasi-experimental study concludes that the integration of specific concrete manipulatives (pebbles, leaves, and ice cream sticks) did not yield a statistically significant effect on third-grade students' conceptual understanding of whole number addition ($p = 0.440$). This primary finding indicates that within short-term instructional interventions, the mere presence of tangible media is insufficient to drive measurable cognitive gains. Rather than diminishing the value of manipulatives, this non-significant result highlights a critical pedagogical reality: concrete media must be accompanied by extended exposure and explicit, structured cognitive scaffolding to effectively bridge tactile exploration with abstract symbolic reasoning.

While the intervention successfully served as a secondary affective catalyst by significantly enhancing students' learning motivation, this heightened engagement did not automatically translate into improved number comprehension. Therefore, educators should not view concrete manipulatives as standalone solutions for cognitive mastery. To optimize mathematical learning outcomes, these tools must be strategically embedded within sustained, developmentally appropriate curricula that prioritize guided questioning and a systematic progression from concrete manipulation to formal mathematical notation.

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