26 (3), 2025, 1679-1704
Jurnal Pendidikan MIPA
e-ISSN: 2685-5488 | p-ISSN: 1411-2531
https://jpmipa.fkip.unila.ac.id/index.php/jpmipa

Optimizing Slow Learners' Understanding through Environment-Based Manipulative Media on the Number Operation Topic

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Abstract: Every individual, including students with special needs such as slow learners, has the right to receive equal education. The current study aimed to examine elementary slow learners' understanding of number operation concepts through the use of manipulative media drawn from their local environment at Pademawu Barat 1 Elementary School, Pamekasan. A qualitative case study design was employed, involving two fifth-grade students identified as slow learners through a diagnostic test, the Colored Progressive Matrices (CPM) psychological assessment, question aires, and interviews. Data were collected through formative and summative assessments, classroom observations, and video documentation, then analyzed descriptively and qualitatively, with validation ensured through source triangulation. An individualized learning intervention was conducted using manipulative media such as ice cream sticks and shell boards that were relevant to the students' coastal environment. The findings revealed that the use of manipulative media combined with structured scaffolding gradually improved students' understanding of number operations, particularly in addition, subtraction, and multiplication. This approach not only helped to concretize abstract mathematical concepts but also enhanced the engagement, independence, and motivation of students who are slow learners. The learning environment became more positive and interactive, fostering greater student participation. In conclusion, this study highlights the importance of incorporating environment-based manipulative media and providing tailored scaffolding to support inclusive mathematics learning in elementary schools, particularly in resource-limited contexts. The findings may serve as a reference for educational development in Indonesia, underscoring the need for educators and policymakers to design adaptive and equitable learning strategies that meet the diverse needs of all students.

Keywords: conceptual understanding, number operations, manipulative media, slow learners, inclusive education.

▪ INTRODUCTION

Every individual has the right to education as an important asset in their life. Following the UN conference in 2006 that affirmed equal rights for individuals with special needs, various countries began implementing inclusive class policies in regular schools (Hernández-Torrano et al., 2022; Mendoza & Heymann, 2022; Pfister et al., 2015). Inclusive education is an educational system that provides opportunities for all students, including those with disabilities as well as those with exceptional talents, to learn alongside their peers (Derzhavina et al., 2021; UNESCO, 2008). It is designed as an educational system that integrates students with special needs and their typically developing peers into the same learning environment (Donath et al., 2023; Jannah et al., 2023; Krämer et al., 2021; Nilholm, 2021; Sari et al., 2022).

One category of students with special needs is those who are slow learners. These students have limited intellectual capacity, which causes them to require more time to

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*Email: ukhti_math@unira.ac.id
DOI: http://dx.doi.org/10.23960/jpmipa.v26i3.pp1679-1704
Received: 27 June 2025
Accepted: 06 August 2025
Published: 08 September 2025

grasp academic concepts (Joseph & Abraham, 2023; Lambert, 2017). Children classified as slow learners may encounter difficulties with attention, memory, or abstract reasoning relative to their peers (Sintawati et al., 2024). A slow learner is a student who has low academic achievement or is slightly below average compared to their peers (Magdum et al., 2025). Therefore, it is important for teachers to understand the characteristics of slow learners and adopt appropriate teaching approaches.

A central factor in addressing the needs of slow learners is the development of conceptual understanding, which enables students to improve across subject areas through logical, critical, and innovative thinking, while being able to explain and apply concepts (Hankeln, 2024; Irshid et al., 2023; Luzano, 2023; Nasayao & Lingo, 2023; Pant et al., 2024). In mathematics learning at the elementary level, conceptual understanding is especially critical. It begins with real-life situations in students' surrounding environment and progresses through the concrete, semi-concrete, and abstract stages (Jannah et al., 2025; Jannah, et al., 2023).

This aligns with Bruner's theory, which emphasizes that mathematics learning should move from concrete to semi-concrete, and finally to abstract representations (Angraini et al., 2023; Darmayanti et al., 2023). At the Elementary School level, understanding mathematical concepts is essential for students because it serves as the initial foundation for mastering mathematics at the next level, especially in number operations such as addition, subtraction, and multiplication. Number operations are one of the essential subjects taught in elementary school. Students' understanding of number operations should have been well-mastered since the 3rd grade. However, evidence from the fifth-grade diagnostic test shows that many students still lack a strong grasp of these concepts, especially in natural number operations. To complement the diagnostic test, students are also administered the Colored Progressive Matrices (CPM) psychological test, which assesses logical reasoning, analytical skills, and basic intellectual potential.

Based on the results of the diagnostic test at Pademawu Barat 1 Elementary School, some slow learners were identified as experiencing difficulties in number operations. One student demonstrated a lack of focus and persistence when completing the addition and multiplication test, earning a test score of 28. Another student struggled to comprehend the concept of natural number operations and required additional assistance, such as having the questions read slowly and carefully to aid understanding, with a test score of 22. The results of the Colored Progressive Matrices (CPM) test confirmed that both students fell into the category of intellectually delayed, indicating that they are slow learners. A key factor underlying these difficulties is that classroom instruction remains the same for all students, without specialized lesson plans, teaching methods, or instructional media tailored to slow learners. Moreover, the teaching of number operations had not been scaffolded through the concrete–semi-concrete–abstract progression using media connected to the students' daily experiences.

Previous research findings highlight several factors contributing to slow learners' difficulties in solving mathematical problems, including limited concentration, shorter attention spans, difficulty understanding multi-step instructions, and longer time needed to learn and comprehend material related to symbols, abstraction, and concepts (Khaira & Herman, 2020; Murdiyanto et al., 2023; Sintawati et al., 2022; Sovia & Herman, 2020). They also often face challenges in generalizing knowledge to new contexts (Listiawati et al., 2023; Setyawan et al., 2021). To address these challenges, scaffolding is needed, where teachers need to provide gradual support until students can achieve independence (Jannah et al., 2019). One effective form of assistance involves using manipulative learning media that are both accessible and familiar to students, thereby facilitating the learning and understanding of number operations (Nurjanah et al., 2020).

Several studies affirm that manipulative media enhance slow learners’ conceptual and practical understanding, make mathematical ideas tangible, help illustrate or explain abstract concepts, and create an engaging learning experience (Aprinastuti et al., 2020; Gonzales, 2022; Lafay et al., 2019; Leow & Kaur, 2024; Parhizkar, 2021; Park et al., 2022). However, most prior studies have not emphasized the use of media directly drawn from students’ daily lives. Tools such as ice cream sticks and seashells, which can be easily seen, touched, and collected, offer a unique advantage because they are familiar, concrete, and culturally relevant to the learners. Because slow learner students are students with special needs, they require special interventions. Thus, instructional strategies should be designed by incorporating resources that align with students' everyday experiences.

In this study, the selection of manipulative media was deliberately tailored to the local context. Since Pademawu Barat 1 Elementary School is situated in a coastal area, students are familiar with seashells and other marine objects. Using locally available, environment-based media not only simplifies the learning process but also captures students’ attention and encourages active participation. Furthermore, these concrete objects help connect students’ real-world experiences with abstract mathematical concepts, creating a meaningful pathway for developing number operation skills.

Although numerous studies have discussed the effectiveness of manipulative media in mathematics learning, a substantial research gap remains regarding its application for slow learners in coastal contexts. Most prior studies have focused on regular students or the use of technology-based media and have been conducted in urban areas. The main difference in this research lies in the local wisdom-based approach, which utilizes simple objects available in the students’ surroundings and relevant to their daily lives. Thus, this research not only contributes to the improvement of mathematical concept understanding among slow learners but also presents an inclusive contextual approach that is easy to implement in schools with limited resources. The conceptual understanding of slow learners in number operations is measured using indicators of mathematical conceptual understanding established in previous studies (Kholid et al., 2021; Uwineza et al., 2023):

Table 1. Indicators of conceptual understanding in this study

Indicator	Description
Restating a concept	Students can restate the concept of addition as "adding," subtraction as "taking away," and multiplication as "repeated addition." *Example*: If the teacher says "3 + 2," students take three ice cream sticks, add 2 more, and then state the result as 5.
Classifying objects according to characteristics (according to their concept)	Students can group numbers based on their place values. *Example*: The teacher asks students to arrange 245, students represent it with two pink sticks (hundreds), four green sticks (tens), and five yellow sticks (units).

Using and selecting procedures or operations	Students can apply addition, subtraction, and multiplication operations using the long multiplication method. *Example*: The teacher asks students to calculate 23 × 4 with ice cream sticks. Students arrange two green sticks (tens) and three yellow sticks (units), multiply 4 × 3 = 12, 4 × 2 = 80, and then add the results to get 92.
Presenting concepts in multiple mathematical representations	Students can use manipulative media such as ice cream sticks and shell boards to represent numerical values in addition, subtraction, and multiplication operations. *Example*: The teacher asks students to solve 24 + 13 with shells: red shells (tens) and white shells (units) are combined to show 37.
Giving examples and non-examples	Students can provide examples of addition and subtraction operations. *Example*: The teacher asks students to distinguish between addition and subtraction using ice cream sticks. Students show 3 + 2 = 5 as addition and identify two groups of 3 sticks as a non-example because it represents multiplication.
Developing the necessary and sufficient conditions of a concept	Necessary condition: adding the number of ice cream sticks and shells if the operation is addition, multiplication, or taking away if the operation is subtraction. *Example*: The teacher asks students to develop the necessary conditions in number operations. Then, students conclude that addition and multiplication add, while subtraction takes away, as seen in expressions like 3 + 2 = 5 and 6 - 2 = 4.
Applying problem-solving concepts or algorithms	Students can solve word problems accurately using manipulative media. *Example*: The teacher gives: “Ani has 12 ice cream sticks, then buys eight more. How many does Ani have now?” Students calculate 12 + 8 = 20 using the sticks and write the solution.

The purpose of this research is to explore slow learners’ understanding of number operation concepts through the use of environment-based manipulative media.

▪ METHOD

Participants

This research involved two slow learners in the fifth grade at Pademawu Barat 1 Elementary School, selected through a diagnostic test of number operation concept understanding, the Colored Progressive Matrices (CPM) psychological test, child psychology questionnaires for parents and teachers, and semi-structured interviews. The diagnostic tests indicated that both students had low levels of understanding of number-operation concepts. At the same time, the CPM results placed them in Grade V (intellectually delayed), thereby meeting the criteria for classification as slow learners.

The selection of research subjects proceeded as follows. First, a diagnostic test was administered to all fifth-grade students to measure their baseline understanding of number operations. Next, interviews were conducted with the students and the homeroom teacher to gather additional information about learning difficulties. After that, the Progressive Matrices (CPM) was administered to identify students who are classified as slow learners. Questionnaires were distributed to teachers and parents to identify students with special educational needs. Based on the combined test and interview results, the researchers held case discussions with class teachers and a psychologist to confirm the two students as research subjects.

In addition to the primary data, the research was supported by supplementary data collected through observations during the learning process, in-depth interviews with teachers and parents, questionnaires on teachers' and parents' perceptions of students' learning abilities, and psychological assessment forms completed by teachers and parents. Observations documented students' responses to the instructional strategies, including participation in discussions, task completion, and interactions with teachers. The interview and questionnaire data provided a comprehensive picture of learning conditions, obstacles faced by students, and the support needed. Additional data sources included the school principal, fifth-grade teachers, and the students' parents.

Research Design and Procedure

This research used qualitative methods with a case study approach to analyze data in depth and scientifically (Creswell, 2014; Creswell & Creswell, 2018). This approach was chosen to obtain a comprehensive understanding of the learning process and the understanding of number operation concepts among slow learners through the application of manipulative media based on local wisdom in elementary schools. The research procedure flow is illustrated in Figure 1.

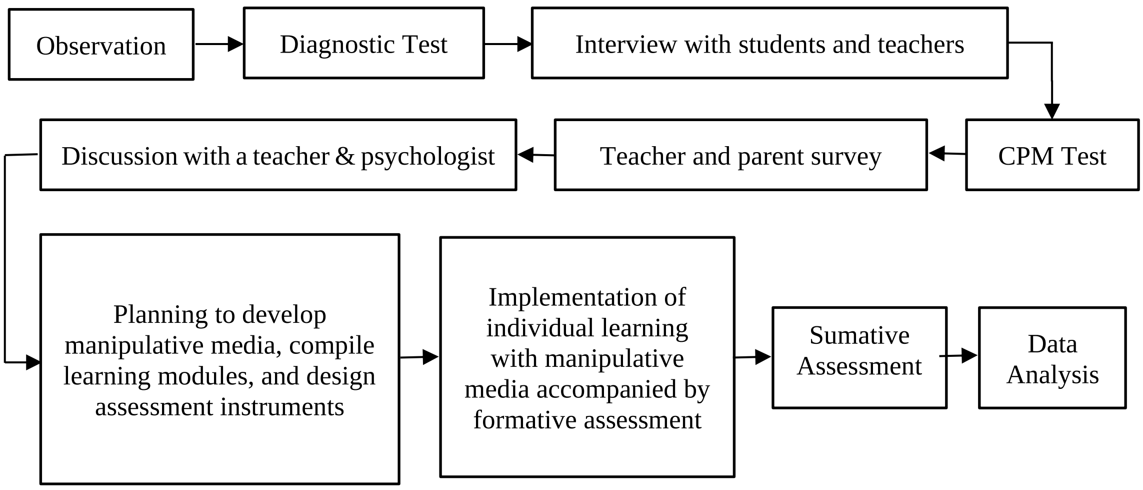

Figure 1. Research procedure flow

The research procedure began with a preliminary study at SDN Pademawu Barat 1 Pamekasan that consisted of classroom observations; administration of a diagnostic test on number operations; interviews with students and teachers about students' understanding of number-operation concepts; administration of the Colored Progressive

Matrices (CPM) psychological test to identify slow learners; distribution of questionnaires to teachers and parents to screen for special educational needs; and case discussions with teachers and psychologists to determine the research subjects. At the planning stage, the researchers developed manipulative media, compiled learning modules, and designed formative and summative assessment instruments tailored to the characteristics of students with learning difficulties, including those with slow learning rates.

The implementation stage included individualized instruction using manipulative media, accompanied by periodic formative assessments to monitor growth in conceptual understanding. Instruction comprised three phases—Phase A, Phase B, and Phase C—delivered in five sessions (Phase A: one session; Phases B and C: two sessions each). Each session lasted 60 minutes and was conducted individually outside regular class hours to provide a conducive learning environment and consistent support. The scaffolding strategies employed included feedback, hints, instruction, explanation, modeling, and questioning. After the instruction was completed, a summative assessment was administered to measure students' final achievement.

Table 2. Scaffolding for student 1

Scaffolding Strategy	Researcher Action	Response from Student 1
Meeting 1 (Phase B: Addition & Subtraction)		
Modelling	Demonstrated how to add using pictures and physical ice-cream sticks/shells.	Demonstrated how to add using pictures and physical ice-cream sticks/shells.
Instructing	Gave step-by-step instructions to set up an addition operation	Followed the instructions and wrote the results on the worksheet.
Explaining	Explained the concept of addition as the sum of two groups of objects and explained the process of subtraction through a simple story.	Understood addition from the visualization of added objects and subtraction as taking away part of the initial amount.
Questioning	Asked for the reason for the reduction, such as "Why has the amount decreased?"	Gave feedback when students incorrectly add the results of multiplication.
Hints	Prompted: "Try counting what is left after taking 3?"	Determined the remaining number of manipulative media
Meeting 2 (Phase B: Multiplication)		
Modelling	Demonstrated multiplication as repeated addition using ice cream sticks	Demonstrated multiplication as repeated addition using ice cream sticks
Feedback	Provided feedback when the student incorrectly added the results of multiplication.	Fixed the calculations and tried again after the correction.
Questioning	Asked, "If there are three groups with two each, how many are there in total?" "How many are there if each of the two groups has three members?"	In the first task, the student used popsicle sticks to form three groups (A. B. C), each comprising two sticks, resulting in a cumulative total of six sticks (2 + 2 + 2 = 6). The second phase entailed forming two groups (A and B), each comprising three popsicle sticks, resulting in a cumulative total

		of six (3 + 3 = 6). Thus, 3 multiplied by 2 equals 6, and 2 multiplied by 3 also equals 6 (3 x 2 = 6 and 2 x 3 = 6).
Meeting 3 (Phase C: Addition & Subtraction)		
Questioning	Asked, "How did you get 34?" while the student was working on a stacked problem.	Described the strategy, though hesitantly.
Feedback	Corrected when the student misplaced the save number	Corrected the answer and retried accordingly.
Explaining	Re-explained the concept of column addition when confusion arose	Listened and retraced steps with more confidence.
Hints	Gave instructions when the student was confused about borrowing techniques	Recognized the need to borrow and reordered steps.
Instructing	Reorganized subtraction steps and provided simple directives.	Followed directions and re-did the column operation.
Meeting 4 (Phase C: Multiplication)		
Questioning	Asked "Where did the 12 come from?" after the student wrote down the result	Attempted to explain the reasoning, though not yet systematic.
Feedback	Corrected inaccurate products or misunderstandings of the basic concept.	Adjusted calculations and clarified understanding.

Table 3. Scaffolding for student 2

Scaffolding Strategy	Researcher Action	Response from Student 2
Meeting 1 (Phase A)		
Modelling	Demonstrated the direct use of media (shells/sticks) for concrete addition.	Imitated the demonstration and counted objects one by one.
Instructing	Gave step-by-step instructions for counting, moving, and arranging the manipulatives.	Followed the directions with close guidance
Hints	Prompted: "Try counting again from here"	Repeated the count from the beginning with the help of ice cream sticks
Feedback	Corrected errors made during addition.	Made corrections and retried slowly.
Meeting 2 (Phase B: Addition & Subtraction)		
Modelling	Demonstrated subtraction and addition using shells/sticks as media	Imitated the method and counted objects, but remained uncertain about the step order.
Instructing	Provided systematic stages in layered reduction and explained "borrowing"	Followed instructions but required repeated guidance.
Explaining	Explained the process of arranging two and three-digit numbers	Tried to rearrange the numbers
Questioning	Asked "How much is left if we take 3?" or "Why are you borrowing here?"	Answered hesitantly, sometimes needing to be guided through choices or affirmations from the researcher
Meeting 3 (Phase B: Multiplication)		
Modelling	Demonstrated repeated groups as a form of simple multiplication (e.g., 3 × 2)	Formed groups but was still unsure how to total them.

Hints	Gave instructions: "How many groups are there?" What colors are they?	Recalculated based on groups
Explaining	Explained the meaning of "multiplication" by simplifying it into a daily life story	Understood better when linked to real-life experiences
Meeting 4 (Phase C: Addition & Subtraction)		
Questioning	Asked "Why did you choose that?" or "What are you doing at this step?"	Tried to explain, even with the help of keywords from the teacher
Feedback	Pointed out errors in computed results	Accepted corrections and improved performance, albeit slowly.
Explaining	Re-explained the concept of place value and the process of saving or borrowing	Tried to remember the sequence of steps, through sometimes reversed them.
Instructing	Provided step-by-step instructions for solving layered problems without media	Followed the steps, but required repetition due to limited focus.
Meeting 5 (Phase C: Multiplication)		
Instructing	Gave directions for arranging numbers and multiplication positions	Followed the steps, needed reinforcement at the final calculation stage
Modelling	Solved one example, then asked the student to imitate	Imitated but struggled to recall initial steps without repetition.
Feedback	Corrected inaccurate products and procedural misunderstandings.	Rewrote and corrected work; sometimes did not notice errors without prompting.

Research data were collected through a diagnostic test, formative and summative assessments, classroom observations, interviews with students, teachers, and parents, and video documentation of the learning process. All data were analyzed descriptively following the qualitative case study data analysis procedures, including data organization, coding, theme development, interpretation of findings, and data validation via source triangulation. To minimize expectancy bias, the validation through source triangulation was conducted by comparing test results, observation and interview results, and video documentation of the learning process. The analysis process was conducted inductively, beginning with coding based on field evidence rather than prior assumptions. The researchers also systematically documented both students' successes and difficulties during instruction, ensuring that interpretations were objective and reflected actual conditions rather than aiming to demonstrate the intervention's success.

Research Instruments

The study employed instruments designed to comprehensively capture data on slow learners' understanding of number-operation concepts. The primary instrument was a diagnostic test on number operations, developed to measure students' initial ability to understand the concepts of addition, subtraction, and multiplication. This test consisted of eight items covering addition, subtraction, and multiplication problems. Additionally, the Colored Progressive Matrices (CPM) psychological test was also used to identify the students' non-verbal cognitive abilities and identify the slow learner category. The CPM comprises visual patterns that students must complete and is widely used in measuring non-verbal intelligence (Gonthier, 2022; Jonsson et al., 2021; Ozawa et al., 2022). During the learning process, formative assessments were administered periodically to monitor students' development and understanding of number operation concepts, identify learning difficulties, and evaluate the effectiveness of manipulative media-based learning. After the entire series of lessons was completed, a summative assessment was given to measure students' final achievement. Observation guides were also used to document student participation, interactions with the teacher, the use of manipulative media, and conceptual errors that emerged during the learning process.

The leading indicators observed include: (1) students' activity level during lessons, such as answering questions and trying to use the media; (2) students' ability to use manipulative media independently or with assistance, including accuracy in arranging and counting concrete objects according to instructions; (3) forms of student-teacher interaction, such as responses to scaffolding (modeling, questioning, hints, etc.) and willingness to try again after receiving feedback; and (4) the types and frequency of conceptual errors, such as misunderstandings of place value, borrowing and carrying techniques, or misapplication of mathematical operations. These observations were conducted systematically to support an in-depth analysis of the learning process and slow learners' conceptual understanding. To enrich the data, interviews based on questionnaires were conducted with teachers and parents to gather additional information regarding learning needs, obstacles, and supports. Additionally, questionnaires for teachers and parents were distributed to gather perceptions relevant to identifying students with special needs.

The selection and design of the manipulative media (ice-cream sticks and a shell board) were based on the characteristics of slow learners, who require concrete and visual learning experiences. Ice-cream sticks were chosen for their simple form, ease of handling, and suitability for counting and grouping to support number operations. This medium was effective for illustrating addition, subtraction, and multiplication as the combination or repetition of tangible objects. The shell board was used to visualize the concept clearly.

The selection of shell board media was also aligned with the local context of the school, specifically *Pademawu Barat* 1 Elementary School, located in a coastal area. This area has easy access to seashells, so using seashells as a learning medium not only supports the accessibility and availability of materials but also enhances students' connection to the subject matter through objects familiar in their daily lives. Thus, the manipulative media used in this research were not only educational but also contextual, as well as culturally and environmentally relevant to the learners.

Data Analysis

The data obtained in this study were analyzed qualitatively using a descriptive approach to reveal the understanding of number operation concepts among slow learners. The analysis was executed according to the stages delineated by Creswell (2014), commencing with the data organization phase, which encompasses the collection and categorization of data from a diagnostic test, formative assessments, summative assessments, student interviews, observations, questionnaires, and video documentation of the learning process.

At the next stage, all the data was analyzed thoroughly to gain a general understanding of its content and to note initial impressions. Furthermore, initial patterns were identified, such as students' difficulties in understanding mathematical symbols, but they showed progress when using concrete media. The third step was the data coding process (open coding), which involved labeling or coding parts of important data. For example:

T : This is 42 + 18, what operation is it? (F1)
S1 : Addition
T : Is it 0? For example, if you have two candies and then add 8 more, how many do you have? (M1)
S1 : 10
T : Yes, if you add it from the front first, but if you do it like this, you add it from the back
first, so 2+8 is how much? (H1)
S1 : 10
T : Come on, try to calculate how much you need to add to 43 to get 56, starting from 44,
45, 46... continue counting until you reach 56. How many are there? (I1)
S1 : 10

T : What is this operation number 1? There are four operations, right? There are four numbers
operations: addition, subtraction, multiplication, and division (Q1& F1)
S2 : Yes
T : Isn't it like this, you do it, come on, let us add it using column addition (I1), you do not
know?
S2 : No
T : You have nine candies, and then they are taken away. Taken away means they are removed. Taken by Rafli, 6 of your candies (M1)
S2 : From 9, Rafli took 6, how many packs of your candies are left? If Rafli takes 6
T : How many candies do you have, ma'am?
S2 : There are 9 of yours

The researcher provided codes such as the interview excerpt above. Next, the codes that have been created are grouped into categories and then developed into main themes. For example, several codes that show students' success in understanding number operations through concrete objects are grouped into the theme "Conceptual understanding develops through concrete media".

The analyzed findings were presented as descriptive narratives, supported by relevant tables and data visualizations. Interpretation was conducted by linking the results to theoretical frameworks and prior studies. To ensure validity, source triangulation was conducted. For instance, when a student showed difficulty with column addition, an interview statement ("I do not know how to do it") was compared with video evidence showing confusion and repeated requests for help. These findings were reinforced by field observation notes, which documented the need for repeated modeling, and by formative assessments indicating that the student was not yet able to solve similar problems independently. Together, these four sources converged to suggest that the difficulty stemmed from a weak understanding of symbolic forms rather than from passive attitudes.

Finally, research conclusions were formulated inductively based on field findings, thus illustrating how appropriate manipulative media and scaffolding can gradually, concretely, and meaningfully enhance slow learners' understanding of number operation concepts.

▪ RESULT AND DISSCUSSION

Identification of Research Subjects

The research subjects were two slow learners in the fifth grade at SDN Pademawu Barat 1. Identification was carried out through a diagnostic test, interviews, psychological assessments using the Colored Progressive Matrices (CPM), as well as evaluations from teachers and parents. The results of the diagnostic test indicated that the first student, SY, experienced persistent difficulties. In addition, SY often used finger assistance and was less meticulous when writing down the numbers that needed to be carried over. In subtraction operations, SY showed confusion when applying the borrowing technique. For multiplication, SY required considerable time to compute because he could memorize multiplication facts only up to the 4s.

Meanwhile, the second student, SN, demonstrated more limited proficiency. On the diagnostic test, SN was only able to answer three questions, with two correct answers and one incorrect answer. SN only understood simple additions within the range of 1-10. Interview data corroborated these findings, indicating that SN required much assistance in understanding addition, subtraction, and multiplication problems.

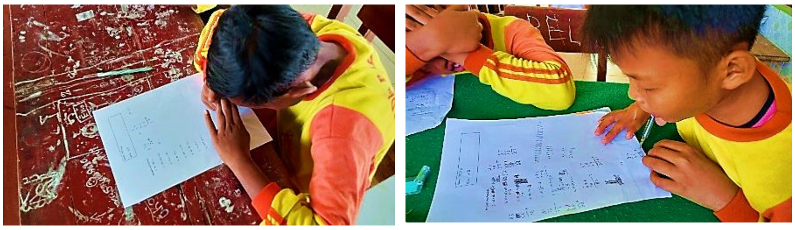

Figure 2. Implementation of the diagnostic test

Following the diagnostic test, a psychological test using the Coloured Progressive Matrices (CPM) was administered to identify the non-verbal cognitive ability level of the students. The CPM test is a culture-fair intelligence measurement tool developed by John C. Raven, specifically designed for children, the elderly, and individuals with special needs, such as slow learners (D'Antonio et al., 2022; Sahithya & Raman, 2021; Singh et al., 2021). This test comprises 36 items divided into three series: A, AB, and B, each presenting a pattern of images with one part missing, where students are asked to complete the pattern (D'Antonio et al., 2022; Jonsson et al., 2021; Ozawa et al., 2022).

The CPM results showed that subject SY answered 13 questions correctly and 23 questions incorrectly, with a percentile of 5, thus falling into grade V: intellectually defective and classified as a slow learner. Meanwhile, subject SN answered 18 questions correctly and 18 questions incorrectly, with a percentile below 10, which also falls into

NORM FOR CPM

Percentile Points	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	10 1/2	11
95	19	21	23	24	25	26	28	30	32	32	33	3
90	17	20	21	22	23	24	26	28	31	31	31	34
75	15	17	18	19	20	21	23	26	28	28	29	31
50	14	15	15	16	17	18	20	22	24	24	26	28
25	12	13	14	14	15	16	17	19	21	22	22	24
10	-	12	12	13	14	14	15	16	18	20	20	21
5	-	-	-	12	13	13	14	15	16	17	17	17

Figure 3. CPM test normcer

GRADE I	INTELLECTUALLY SUPERIOR if his scores lies at or above the 95th percentile for people of his age-group.
GRADE II	DEFINITELY ABOVETHE AVERAGEIN INTELLECTUAL CAPCITY If his score lies at or above 75th percentile, And II +, if his score lies at or above the 90th percentile
GRADE III	INTELLECTUALAVERAGE If his score lies between the 25th and 75th percentile; And III+, if his score greater than the median or 50th percentile. Or III -, if his score is less than the median.
GRADE IV	DEFINITELY BELOW AVERAGE IN INTELLECTUAL CAPACITY If his score lies at or below the 25th percentile, IV -, if his score lies at or below the 10th percentile.
GRADE V	INTELLECTUALLY DEFECTIVE If his score lies at or below the 5th percentile for his age-group

Figure 4. Level of intelligence

grade V: intellectually defective. These designations were corroborated by an independent psychological assessment.

The use of CPM provided a more accurate picture of students' cognitive profiles, which can be used as a basis for designing appropriate learning strategies, one of which is the use of manipulative media (Antara et al., 2024; Bartolini & Martignone, 2014; Ummah et al., 2019). Based on the results of the identification, instruction was designed to help students understand mathematical concepts gradually, starting from the concrete stage, semi-concrete, to abstract understanding. With this approach, it is hoped that slow learners can develop a more optimal understanding of number operation concepts according to their respective cognitive abilities.

Individual Learning Outcomes and Formative Assessment

To support students with special needs at SDN Pademawu Barat 1 in understanding the concept of number operations, the manipulative media was developed using ice cream sticks and a shell board (Figure 5). The selection of these media was based on the results of the initial (diagnostic) assessment, as well as the discussions and validation with expert lecturers and teachers at the school. The manipulative media were designed to help slow learners understand number operations concretely by involving direct learning experiences. With manipulative media, slow learners can understand and remember the concept of number operations easily (Jannah et al., 2025).

Figure 5. Manipulative media of ice cream sticks and shell boards

In addition to the manipulative media, we also developed teaching modules that incorporated these media to strengthen concrete conceptual understanding. Preparation of the modules was discussed with teachers and informed by initial assessments from the diagnostic test and the Colored Progressive Matrices (CPM). Based on these results, it was agreed that student SN would begin with Phase A, while student SY would begin with Phase B, aligned with their respective readiness levels and cognitive profiles.

The discussion on the development of the modules resulted in several important agreements. First, manipulative media such as ice-cream sticks and shell boards would be used to support gradual, concrete learning. Then, Learning Outcomes (LO) and the Learning Objectives Pathway (LOP) would be adapted to meet the needs of slow learners, ensuring instruction remained focused and aligned with ability. Third, instruction would be individualized and scaffolded. Fourth, learning activities would progress from concrete tasks with manipulative media and include both formative and summative assessments. All activities were designed to foster student independence, enabling learners to complete tasks independently.

Figure 6. Discussion with teachers in the preparation of teaching modules

Table 4. Learning outcomes of number operations for slow learners

Student	Diagnostic Test Results	Results of Each Phase
SY	Showed persistent difficulties. Frequently relied on finger counting and was less meticulous with carried digits	In phase B, 4 out of 7 indicators of conceptual understanding were met, namely: 1. Restating a concept where SY could express addition by adding, subtraction by subtracting,

	(regrouping) in addition. In subtraction, SY showed confusion with the "borrowing technique," for example, if the units are 2-3, SY sometimes wondered whether to borrow or not. Additionally, in using the column multiplication calculation, SY required extended time and had memorized facts only up to the 4s.	and multi-digit addition in the form of multiplication. 2. Classifying objects according to specific properties (according to the concept), where SY could group place values in whole numbers up to 100. 3. Providing examples where SY was able to read problems according to their operations and can identify which are addition, subtraction, and multiplication operations. 4. Presenting concepts in various mathematical representations, where SY was able to arrange shells and ice cream sticks according to the requested addition and subtraction operations, but required guidance when solving problems requiring the missing addend concept
		In Phase C, 5 out of 7 indicators of conceptual understanding were met, namely: 1. Restating a concept where SY could state addition as a technique for combining two numbers, could state subtraction as a technique for reducing, and could restate the concept of multiplication. 2. Classifying objects according to specific properties (according to the concept), where SY could group place values in a number. 3. Providing examples and non-examples where SY was able to read a problem and show the difference between addition, subtraction, and multiplication operations in a mixed arithmetic problem. 4. Presenting concepts in various mathematical representations, where SY was able to arrange shells and ice cream sticks according to the requested number value. 5. Developing necessary and sufficient conditions for a concept where SY was able to add/remove the number of shells and sticks that had been arranged according to the operation.
SN	Answered three questions. Provided correct answers for questions 1 and 4, but an incorrect answer for question 2. Understood only simple additions within 1–10. Interviews corroborated a need for substantial assistance with addition, subtraction, and multiplication.	In phase A, 3 out of 7 indicators of concept understanding were met, namely: 1. Restating a concept where SN could state addition as the activity of adding two concrete objects (sticks/shells) and subtraction by taking away two objects. 2. Classifying objects according to certain characteristics (according to the concept), where SN was able to group the number of shells according to their numerical value. 3. Providing examples where SN was able to read the problem well and can show which is the addition or subtraction operation.

	In phase B, the concept understanding indicator was not met because SN had not yet grasped the concept of addition and subtraction operations of whole numbers up to 100. This was evidenced by SN's difficulty in adding units to units, tens to tens, and hundreds to hundreds, even with the help of manipulative media. SN struggles to arrange the representation of hundreds, tens, and units.
	In phase C, 3 out of 7 indicators of conceptual understanding were met, namely: 1. Restating a concept where the student could express addition as the technique of "adding," subtraction as "taking away," and multiplication as the concept of "repeated addition." 2. Classifying objects according to specific properties (according to the concept), where the student could state the place value in whole numbers up to 1,000. 3. Providing examples where the student could read the problem well and could identify addition, subtraction, and multiplication.

Figure 7. Use of the shell board by the research subject

Figure 8. Use of ice cream sticks by the research subject

The slow progress exhibited by the slow learners aligned with the findings of Fitriana, et al. (2024) and Hikma, et al. (2025) who reported that slow learners would require more time to understand basic mathematical concepts. In addition, Handayani, et al. (2024) and Putri, et al. (2024) also emphasized that manipulative media can provide the necessary support for slow learners who have difficulty understanding numeracy concepts. Manipulative media can also increase student motivation and engagement in the learning process.

Summative Assessment Results

After all individual learning sessions were completed, a summative assessment was administered to measure the students' final achievement in understanding number operations. SY experienced an increase in score from 28 to 100, where SY mastered all the tested number operation concepts, including mixed operations, addition and subtraction in word problems, and the application of multiplication as repeated addition in the context of word problems. Meanwhile, SN's score increased from 22 to 75, indicating an improvement in understanding, although some errors persisted, particularly in final answer accuracy and completeness. Nevertheless, SN demonstrated understanding of the basic concepts of addition and multiplication in word problems. These results indicate that SN made progress, albeit more slowly, with a continued need for guidance in certain areas.

Manipulative media such as ice cream sticks and shell boards play an important role in clarifying abstract concepts; they provide students with opportunities to experiment, make decisions, and build independence and confidence in solving math problems. Both subjects were able to complete the assessment independently, which simultaneously reflects an improvement in conceptual understanding as well as the development of learning independence in slow learners. With concrete learning experiences, students are more motivated to try, explore, and gradually begin solving calculations on their own (Aghisni, et al, 2025; Irmayani, et al., 2024; Putri, et al., 2024).

The Role of Manipulative Media and Scaffolding

Overall, the learning outcomes for slow learners indicate that the use of manipulative media such as ice cream sticks and seashell boards effectively helps slow learners connect concrete objects with abstract mathematical symbols. These media make it easier for students to understand number operations gradually, whether in addition, subtraction, or multiplication. This finding aligns with research showing that manipulative media are highly effective in enhancing special-needs students' understanding of mathematical concepts (Antara et al., 2024; Aprinastuti et al., 2020; Gonzales, 2022; Lafay et al., 2019). However, some studies report that virtual manipulative media can be more effective in helping slow learners learn mathematics (Lafay et al., 2019; Lin Sen et al., 2017; Nurjanah et al., 2020; Park et al., 2022).

Concrete, visual, and engaging learning experiences are key advantages of manipulative media. By incorporating physical activities in learning, students not only observe but also directly engage with the material, making abstract mathematical concepts easier to understand (Bartolini & Martignone, 2014; Listiawati et al., 2023). Consistent with these results, previous studies have shown that ice-cream-stick media improve slow learners' counting ability and support number-concept development because of their simplicity and ease of use (Muis, 2023; Rahayu, et.al., 2024; Sholihah & Trimurtini, 2023).

In addition, research by Dethan et al. (2022) and Jannah et.al. (2021) indicates that slow learners can understand number operations well through manipulative media, such as using seashells, which provide a more tangible and enjoyable learning experience, especially for multiplication, as it involves repeated addition. Moreover, ice-cream-stick media is well suited to improving understanding and calculation skills in addition and subtraction (Jannah et al., 2025; Jannah, et al., 2023; Jannah, et al., 2021).

The use of such manipulative media has a positive impact not only on conceptual understanding but also on student activity, learning interest, learning outcomes, and active engagement during the learning process (Isnaniah & Imamuddin, 2020; Ulyani & Qohar, 2021; Ummah et al., 2019). The use of ice-cream sticks and shell boards has been shown to improve slow learners' mathematical understanding, make material easier to master, and enhance overall learning outcomes (Ardhia, et.al., 2024; Bintang, et al., 2024; Permatasari, et al., 2022; Septiani, et al., 2024).

Manipulative media effectively help slow learners understand number operations concretely and gradually (Ambarwati et al., 2022; Ndasi, et al, 2024). The results of this study are consistent with findings by Jannah et al. (2021) and Jannah et al. (2025), which state that slow learners in inclusive classes can better understand the concept of multiplication through manipulative media, such as using seashells.

Specifically, the shell board is highly useful for slow learners in understanding the concept of place value. This medium allows students to directly see the difference between units, tens, and hundreds by grouping shells into columns that represent specific place values. By physically moving and counting the shells, students can recognize that, for example, ten shells in the unit's column can be converted into one shell in the tens column. This activity fosters a concrete understanding of number structure and reinforces the place-value system.

The tangible and easily movable shells also make it easier for students to understand the process of "borrowing" or "carrying" when performing stacked subtraction and addition operations. When students are asked to arrange a certain amount, they can immediately see the number of shells available and determine whether they need to borrow from the place value above it. Thus, instruction based on manipulative media such as ice cream sticks and shell boards, combined with gradual individual learning, has proven effective in enhancing the understanding of number operation concepts among slow learner students. This strategy also provides opportunities for students to develop independent learning skills.

This research also shows that providing scaffolding plays an important role in helping slow learners understand the material (Jannah et al., 2019b; Pfister et al., 2015; Susilo & Prihatnani, 2022; van de Pol et al., 2010; van Oers, 2019). For subject SY, scaffolding was more focused on reinforcing concepts with a dominance of hints, explaining, and questioning to address precision errors, such as rounding results and borrowing techniques.

The questioning approach was proven effective in helping SY revisit steps that were missed or performed automatically without rechecking. Directed questions that encouraged SY to verify their own answers could enhance metacognitive awareness and reduce errors due to carelessness. For example, when SY directly wrote the result without properly borrowing, the teacher then provided questioning as scaffolding:

Teacher	: We have two minus 9. Can we subtract it directly?
SY	: No, you cannot; you have to borrow.
Teacher	: Where did you borrow from earlier?

SY (looking back at his work): Oh, I have not borrowed yet... I forgot.
Teacher : If you borrow from the 5 in the tens place, what does it become?
SY : Five becomes four. Two in the units become twelve.
Teacher : Now, twelve minus nine is how much?
SY : Three

The dialogue shows that through questioning, SY was directed to find and correct his own mistakes. This approach was more effective than just being told the answer, as it fostered thinking awareness and self-control in the problem-solving process. Patterns of questions like this gradually cultivated SY’s habit of reviewing his steps, thereby minimizing technical errors due to carelessness.

Unlike SY, SN required more intensive scaffolding from the outset, including instructing, modeling, explaining, and hints, because SN had difficulty understanding basic concepts, using manipulatives, and interpreting word problems. The slower development typical of slow learners can stem from several interrelated factors. In general, slow learners have below-average cognitive functioning and therefore require more to process information, retain concepts, and generalize problem-solving strategies.

Based on the results of observations and documentation in this study, SN struggled to recognize written instructions, understand mathematical symbols, and independently apply manipulative media. Additional contributing factors included limitations in working memory and visual-spatial processing, which are crucial in understanding the place value and the procedures of carrying/borrowing. SN also exhibited quicker cognitive fatigue, required longer processing times, and more frequent repetition. Initial assessments and interviews further indicated that SN had a limited background in learning experiences and lacked support in individual learning at home, which likely slowed conceptual development. In general, slow learners’ abilities improve when they are given more time, repetition, and assistance tailored to their developmental level. Thus, tailored scaffolding strategies, whether in the form of questioning to reinforce precision (as with SY), or modeling and instructing to build understanding from the ground up (as with SN), are important approaches in supporting the success of mathematics learning for students with special needs.

Individualized scaffolding was shown to enhance the understanding of both research subjects, as reflected in the summative assessment results, which improved substantially following manipulative–media–based instruction. These findings are in line with previous research results indicating that the application of scaffolding combined with manipulative media helps students understand mathematical operations concretely, gradually, while developing mathematical problem-solving skills (Antara et al., 2024; Aprinastuti et al., 2020; Jannah et al., 2025; Jannah, Putra, et al., 2021; Pfister et al., 2015; Susilo & Prihatnani, 2022; van Oers, 2019).

For teachers, these findings carry important practical implications. Scaffolding strategies should be flexible and responsive to each learner’s abilities. Teachers can start by providing more explicit assistance such as modeling and instructing, then gradually shift to hints and questioning to train independent thinking skills. In addition, the use of simple and easily obtainable manipulative media in the school environment can be an effective tool for bridging abstract concepts. Teachers are also encouraged to conduct formative assessments regularly to monitor students' progress and adjust teaching interventions. This approach not only supports a deeper understanding of mathematics but also strengthens students' independence in learning.

▪ CONCLUSION

The use of manipulative media in the form of ice cream sticks and seashell boards was effective in enhancing slow learners' understanding of number operation concepts and promoting independent learning. Gradual, needs-based scaffolding further strengthened conceptual development, making learning more systematic and meaningful. Assessment results showed substantial improvement in both content mastery and students' independence.

These findings may serve as a reference for educational advancement in Indonesia, particularly in inclusive education for students with special learning needs, such as those with slow learning abilities. This underscores the need for educators and policymakers to formulate adaptive and equitable learning strategies for all students. However, this study had several limitations. First, the limited number of subjects (two slow learners) means the results cannot be generalized to the entire population of students with special needs. Second, the intervention was conducted over a relatively short period and was limited to basic number operations (addition, subtraction, and multiplication), not covering other mathematical topics that may require different approaches.

Based on these limitations, future research should: (a) involve more subjects from diverse backgrounds and educational levels to obtain more representative results; (b) expand the scope of materials beyond number operations to include other topics such as measurement, fractions, or geometry; and (c) investigate the long-term effectiveness of manipulative media and scaffolding in supporting students' cognitive development and learning independence.

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