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THE USE OF DIENES BLOCKS TO IMPROVE MULTIPLICATION SKILLS AMONG FIFTH-GRADE STUDENTS WITH INTELLECTUAL DISABILITIES

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Abstract

This study aimed to improve multiplication skills among fifth-grade students in an inclusive elementary school through the use of Dienes Blocks as a concrete mathematical learning medium. The study employed a Classroom Action Research design based on the Kemmis and McTaggart model, consisting of planning, action, observation, and reflection stages conducted in two cycles. The participants were 24 fifth-grade students at SDN 002 Rantau Pulung, including five students with intellectual disabilities who constituted the primary focus of the intervention. Data were collected through observation, multiplication tests, and documentation and analyzed using descriptive quantitative and qualitative procedures. Learning outcomes were assessed based on mean scores and classical mastery, with a minimum mastery criterion of 75 and a classical mastery target of 80%. The findings demonstrated a progressive improvement in students' multiplication performance. The mean score increased from 72.16 in the pre-test to 75.88 in Cycle I and 79.21 in Cycle II. Classical mastery also increased from 66.67% to 79.17% and subsequently to 91.67%. Classroom observations indicated that Dienes Blocks enabled students to visualize multiplication as repeated grouping and supported more active engagement with mathematical concepts. The findings suggest that Dienes Blocks, when combined with structured instruction, repeated practice, and teacher scaffolding, can support multiplication learning in inclusive elementary classrooms, particularly for students with intellectual disabilities.

Keywords: Dienes Blocks, multiplication skills, intellectual disabilities, inclusive education, elementary mathematics, classroom action research.

Abstrak

Penelitian ini bertujuan untuk meningkatkan keterampilan perkalian di kalangan siswa kelas lima di sebuah sekolah dasar inklusif melalui penggunaan Balok Dienes sebagai media pembelajaran matematika konkret. Penelitian ini menggunakan desain Penelitian Tindakan Kelas berdasarkan model Kemmis dan McTaggart, yang terdiri dari tahap perencanaan, tindakan, pengamatan, dan refleksi yang dilaksanakan dalam dua siklus. Peserta penelitian adalah 24 siswa kelas V di SDN 002 Rantau Pulung, termasuk lima siswa penyandang disabilitas intelektual yang menjadi fokus utama intervensi. Data dikumpulkan melalui observasi, tes perkalian, dan dokumentasi, kemudian dianalisis menggunakan prosedur deskriptif kuantitatif dan kualitatif. Hasil belajar dinilai berdasarkan nilai rata-rata dan penguasaan klasik, dengan kriteria penguasaan minimal 75 dan target penguasaan klasik sebesar 80%. Temuan menunjukkan peningkatan *progresif dalam kinerja perkalian siswa. Nilai rata-rata meningkat dari 72,16 pada pra-tes menjadi 75,88 pada Siklus I dan 79,21 pada Siklus II. Penguasaan klasik juga meningkat dari 66,67% menjadi 79,17% dan selanjutnya menjadi 91,67%. Pengamatan di kelas menunjukkan bahwa Balok Dienes memungkinkan siswa memvisualisasikan perkalian sebagai pengelompokan berulang dan mendukung keterlibatan yang lebih aktif dengan konsep-konsep matematika. Temuan ini menunjukkan bahwa Balok Dienes, bila dikombinasikan dengan pengajaran terstruktur, latihan berulang, dan bimbingan guru, dapat mendukung pembelajaran perkalian di kelas sekolah dasar inklusif, khususnya bagi siswa dengan disabilitas intelektual.*

Kata kunci: *Dienes Blok, keterampilan perkalian, disabilitas intelektual, pendidikan inklusif, matematika sekolah dasar, penelitian tindakan kelas,*

INTRODUCTION

Mathematics is one of the fundamental subjects in elementary education because it not only serves as a vehicle for developing logical and systematic thinking skills but also supports students' independence in handling various everyday activities. Numeracy skills including understanding numbers and basic arithmetic operations are related to the ability to use quantitative information in functional contexts such as counting money, determining the number of objects, managing time, and solving practical problems. For students with intellectual disabilities, mastery of mathematics takes on even greater importance, as numeracy skills can contribute to their independence and participation in social life. Systematic reviews indicate that students with intellectual disabilities still have the capacity to develop numeracy and arithmetic skills if they receive educational interventions tailored to their learning characteristics and needs (Schnepel & Aunio, 2022).

Nevertheless, teaching mathematics to students with intellectual disabilities presents pedagogical challenges that differ from those encountered when teaching the general student population. Characteristics of cognitive development, limitations in working memory, difficulties retaining information, and challenges in generalizing concepts can cause the process of understanding abstract mathematical concepts to proceed more slowly. In the context of inclusive classrooms, these issues become even more complex because teachers must accommodate varying abilities within a single learning environment. Longitudinal research on students with intellectual disabilities in inclusive classrooms shows that their mathematical development is not homogeneous; their prior knowledge profile is a key predictor of mathematical ability development. These findings reinforce the need for instruction tailored to students' individual knowledge and needs, rather than simply following uniform learning targets (Schnepel et al., 2020).

This issue is particularly relevant in teaching multiplication. Multiplication is not merely the ability to memorize multiplication facts but a concept that requires an understanding of quantitative relationships, grouping, repeated addition, and the connection between concrete representations and mathematical symbols. When instruction emphasizes procedural memorization, students may know the answer to a multiplication fact without understanding why that answer is correct. For students with intellectual disabilities, reliance on rote memorization can become a more serious problem because limitations in retaining and retrieving information can hinder the flexible use of multiplication facts. Studies on the mathematical thinking abilities of students with intellectual disabilities in Indonesia also indicate that some students struggle to recall multiplication facts and concepts as well as to connect mathematical information when solving problems (Afiani et al., 2024).

Difficulties with multiplication operations have also been specifically identified in research involving students with intellectual disabilities. Putri and Damri (2020), for example, demonstrated that understanding of multiplication concepts among students with mild intellectual disabilities can be enhanced through the use of concrete media such as number balances. The improvement in ability observed following the intervention indicates that visual and manipulative representations can help students build an understanding of multiplication operations that were previously difficult to grasp abstractly. Similarly, Sudiryo's (2020) study showed that mathematics instruction using the Iko method can be used to improve learning outcomes in multiplication for students with intellectual disabilities. These findings suggest that instructional interventions providing more explicit visual and procedural structures have the potential to address students' difficulties when dealing with abstract mathematical operations.

The need for mathematics instruction based on concrete representations is further reinforced by international studies. Schnepel and Aunio (2022), in a systematic review of mathematics interventions for elementary school students with intellectual disabilities, emphasize the importance of structured interventions to develop numeracy, arithmetic, and problem-solving skills. This review indicates that mathematics instruction for students with intellectual disabilities must take into account their initial ability levels, the intensity of the intervention, and teaching strategies that allow students to gain learning experiences in a gradual manner. Bouck and Long (2023) also point out that research on mathematics interventions for students with mild intellectual disabilities is growing, but the need for learning practices that are truly evidence-based and aligned with students' characteristics remains a key research priority.

One relevant approach to bridging abstract mathematical concepts with students' learning experiences is the use of concrete manipulatives. Manipulatives allow students to see, touch, move, group, and construct representations of quantity directly. Through these experiences, mathematical symbols are no longer presented as purely abstract information but take on physical representations that can be observed and manipulated. Research by Zhang et al. (2022) shows that learning following a *concrete–representational–abstract* sequence can support the mathematics learning of students who struggle with the subject. This approach highlights the importance of a systematic transition from concrete objects to visual representations and, subsequently, to abstract symbols.

This argument is also supported by the research by Lafay et al. (2023), which examined the use of manipulatives to aid the understanding of place value among children at risk of experiencing difficulties in learning mathematics. The study emphasizes that the effectiveness of manipulatives is determined not only by the presence of concrete objects but also by the extent to which the physical characteristics of those objects conceptually represent the mathematical structures being studied. Thus, concrete materials must be selected and used pedagogically so that students do not merely manipulate the objects but are able to connect those manipulations to the mathematical concepts they represent.

In the context of students with special needs, evidence regarding the benefits of manipulatives is also growing. Jimenez and Besaw (2020) found that virtual manipulatives, when combined with story-based learning, systematic instruction, graphic organizers, and physical manipulatives, can be used to develop early numeracy skills in students with intellectual disabilities and autism. Shurr et al. (2021), through a comparison of virtual and concrete manipulatives among elementary school students with autism, also identified manipulatives as a crucial tool for representing abstract mathematical concepts in a way that is more accessible to students. Meanwhile, Park et al. (2022), through a synthesis of *single-case* studies, demonstrated that virtual manipulatives can support improvements in the mathematical performance of students with learning difficulties, particularly when object manipulation is used to build mathematical representations interactively.

The use of concrete media is also relevant to the learning characteristics of students who require explicit and step-by-step support. Vostanis et al. (2021) demonstrated that the *precision teaching* framework can improve the mathematical abilities of students with intellectual and developmental disabilities through systematic practice and performance monitoring. Meanwhile, Bouck et al. (2021) demonstrate that the use of visual representations and explicit support can help students with developmental disabilities understand real-life mathematical problems and generalize problem-solving strategies. Root et al. (2022) also demonstrated the effectiveness of *modified schema-based instruction*, delivered by teachers in small groups, in improving multiplication problem-solving skills among students with autism and intellectual disabilities. These findings indicate that mathematics instruction for students with intellectual disabilities requires clear representations, a systematic learning structure, and support that gradually guides students toward independence.

From an inclusive education perspective, the use of manipulatives is not only related to improving learning outcomes but also to providing more equitable access to mathematics content. Gervasoni and Peter-Koop (2020) emphasize that inclusive mathematics education requires attention to how all students can gain access to and meaningfully participate in mathematics learning. Research by Schnepel et al. (2022) further found that inclusive educational settings can foster positive mathematical development for students with intellectual disabilities, but their effectiveness still depends on the quality and appropriateness of the instruction provided. Therefore, inclusion should not be understood merely as the presence of students with special needs in regular classrooms; rather, it must be realized through instructional adaptations that enable them to understand the material in accordance with their needs and learning profiles.

This issue is becoming increasingly critical because mathematics instruction for students with disabilities still risks being confined to procedure-oriented and rote-learning approaches. Tan et al. (2022) critique the tendency in mathematics education for students with disabilities to provide access to low-level mathematics with an excessive emphasis on routine procedures and narrow skills. This situation can limit students' opportunities to build meaningful mathematical understanding. Therefore, mathematics interventions should not only aim to improve test scores but also develop conceptual understanding through learning experiences that allow students to construct mathematical meaning.

Empirical findings from Grade 5 at SDN 002 Rantau Pulung, an inclusive elementary school, reveal issues consistent with this gap. Of the 24 students in the class, five students with intellectual disabilities struggled to solve multiplication problems. Initial observations showed that students tended to understand multiplication by memorizing multiplication tables and were not yet able to consistently relate them to the concept of repeated addition. When presented with problem variations that differed from the examples they had memorized, students struggled to determine a solution strategy. This situation indicates that the main issue lies not merely in the ability to recall multiplication facts, but also in the lack of established conceptual connections between quantities, groups of objects, the multiplication operation, and mathematical symbols.

This issue is exacerbated by a learning approach that still relies heavily on textbooks and verbal explanations, while the use of concrete materials or manipulatives has not yet become an integral part of multiplication instruction. In fact, research on inclusive mathematics education shows that teacher support, instructional adaptation, and the use of appropriate learning resources are critical factors in providing access to mathematics learning for students with diverse needs (Gervasoni & Peter-Koop, 2020; Supportive Factors in Inclusive Mathematics Education, 2023). Under these circumstances, learning that relies solely on symbols and rote memorization risks widening the gap between curriculum demands and students' actual abilities.

Dienes blocks serve as a relevant alternative because their characteristics allow number concepts and quantitative relationships to be physically represented. Dienes blocks, or *base-ten blocks*, consist of units, rods, discs, and cubes that can be used to construct representations of place value and arithmetic operations. In multiplication instruction, this material can be used to form groups of quantities so that students can observe that multiplication is the process of combining a number of groups that have the same quantity. Thus, students are not immediately directed toward symbols such as $3 \times 4 = 12$, but first gain concrete experience with three groups, each consisting of four units, then connect this to pictorial representations, and finally to mathematical symbols. This principle aligns with evidence regarding the importance of manipulatives and the concrete–representational–abstract transition in mathematics instruction for students with learning difficulties (Zhang et al., 2022; Lafay et al., 2023).

The use of Dienes blocks is also supported by research specifically examining manipulatives in multiplication operations for students with intellectual disabilities. Putri and Damri (2020) found that number balance scales can improve the understanding of multiplication concepts among students with mild intellectual disabilities, while Olievia et al. (2023) found that the use of multiplication boards can enhance the multiplication skills of students with mild intellectual disabilities. Wadilah et al. (2023) also demonstrated that students with intellectual disabilities exhibit diverse abilities in representing multiplication operations through writing, drawings, and mathematical expressions. These findings indicate that multiplication skills can be developed using materials that provide alternative representations of mathematical symbols; however, they do not specifically address how Dienes blocks—as manipulatives based on place value and quantity grouping—can be utilized through Classroom Action Research to improve the multiplication skills of students with intellectual disabilities in inclusive classrooms.

Thus, there is a research gap in three aspects. First, research on mathematics learning for students with intellectual disabilities has extensively addressed numeracy interventions, problem-solving, manipulatives, and explicit instruction; however, studies specifically utilizing Dienes Blocks to build conceptual understanding of multiplication among students with intellectual disabilities in the context of an inclusive fifth-grade elementary school classroom remain limited. Second, research on Dienes Blocks has more often focused on place value, whole numbers, addition, or the mathematical abilities of elementary school students in general, while their use to address multiplication difficulties among students with intellectual disabilities has not been extensively studied empirically. Third, there is still a need for classroom-based action research that documents the cyclical process of learning change, starting from the initial condition, the implementation of manipulatives, student responses, teacher reflections, to improvements in multiplication skills.

These gaps provide the basis for this study to apply Dienes Blocks as manipulatives in teaching multiplication operations to students with intellectual disabilities in the fifth grade at SDN 002 Rantau Pulung. This study does not treat Dienes Blocks merely as a visual aid but as a pedagogical medium to transform the concept of multiplication from a symbolic procedure into a concrete, representational, and ultimately abstract experience. The intervention was designed through Classroom Action Research so that each cycle could be used to identify learning barriers, evaluate student responses, refine learning strategies, and improve the quality of actions in the next cycle. This approach is expected to bring about changes not only in the ability to obtain multiplication answers but also in the ability to understand the relationship between groups of objects, repeated addition, and the multiplication symbol.

Conceptually, this study is based on the assumption that improving the mathematical abilities of students with intellectual disabilities cannot be achieved solely through increased practice frequency or memorization of multiplication facts. Instruction must provide representations that align with how students understand quantity, offer opportunities to manipulate objects directly, provide systematic *scaffolding*, and gradually connect concrete experiences with visual representations and mathematical symbols. Empirical evidence regarding mathematics interventions for students with intellectual disabilities supports the importance of structured, individually tailored strategies (Schnepel & Aunio, 2022; Bouck & Long, 2023), while research on manipulatives indicates that concrete representations can serve as a bridge to understanding more abstract concepts (Zhang et al., 2022; Thomas et al., 2025).

Therefore, this study is important to generate empirical evidence regarding the effectiveness of using Dienes Blocks in improving the multiplication skills of students with intellectual disabilities in an inclusive classroom setting. In addition to providing practical contributions to teachers in designing more concrete and adaptive mathematics instruction, this study also has the potential to enrich the field of inclusive mathematics education by demonstrating how manipulatives can be used to bridge the gap between students' cognitive characteristics and the demands of mathematics learning. Thus, this study is aimed not only at improving numeracy achievement but also at reinforcing the principle that students with intellectual disabilities have the right to meaningful, conceptual, and accessible mathematics learning experiences.

METHOD

Research Design

This study employed Classroom Action Research (CAR) with a *classroom-based intervention* approach to improve the multiplication skills of students with intellectual disabilities through the use of Dienes blocks. The choice of CAR was based on the study's focus on directly addressing learning problems through systematic, reflective, and repeated actions in a real classroom context. The research design follows the Kemmis and McTaggart action cycle, which consists of four main stages: *planning*, *acting*, *observing*, and *reflecting*. These four stages are carried out cyclically, so that findings from one cycle serve as the basis for refining the intervention design in the next cycle (Meiyanti et al., 2025). The study was designed to include at least two cycles. Before the intervention was implemented, all participants took a pre-test to assess their initial multiplication skills. Subsequently, the intervention was carried out through concrete manipulation-based learning using Dienes blocks in Cycle I and Cycle II. Evaluations in each cycle were used to identify changes in students' academic abilities and learning activities, as well as to determine which aspects of learning needed improvement. If the success indicators have not been met after Cycle II, the study may procedurally proceed to the next cycle. Thus, the research design is not only aimed at measuring changes in learning outcomes but also at understanding how modifications to instructional strategies can address the needs of students with intellectual disabilities. The study was conducted over approximately two months, specifically May–June 2026. The research stages include research preparation, instrument development, coordination with the school, initial observation, implementation of interventions, evaluation of each cycle, reflection, data analysis, and preparation of the research report.

Research Setting and Participants

The research was conducted at SDN 002 Rantau Pulung, an elementary school that implements an inclusive education system. The school's inclusive context allows regular students and students with special needs to participate in the learning process within the same classroom environment. This setting was chosen because the study focuses on the mathematics learning needs of students with intellectual disabilities in an inclusive classroom context, specifically regarding multiplication. The study participants consisted of 24 fifth-grade students, including five students with intellectual disabilities, who were the primary focus of the intervention. These five students experienced difficulties in understanding the concept of multiplication, particularly in connecting mathematical symbols with the meaning of multiplication as repeated addition. They also showed a tendency to rely on memorizing multiplication facts rather than building conceptual understanding. These conditions formed the basis for an intervention using concrete objects and manipulatives. Although the five students with intellectual disabilities were the primary focus of the analysis, all students in the class remained involved in the learning process. This strategy was employed to uphold the principles of inclusive education and prevent the segregation of students based on ability. Thus, the intervention was not merely positioned as an individual remedial program but as a learning strategy applicable in a heterogeneous classroom setting.

Intervention: Dienes Blocks-Based Learning

The learning intervention uses Dienes Blocks as concrete manipulatives to help students build connections between concrete representations, visual representations, and mathematical symbols. The use of manipulatives serves as a bridge from direct experience to a more abstract understanding of the concept of multiplication. In the initial stage, the teacher introduced the Dienes Blocks and gave students the opportunity to observe, handle, group, and arrange the blocks. Teachers then connect these manipulative activities to the concept of multiplication. For example, the operation 3×4 is represented by three groups, each consisting of four units. Students are guided to count each group and then determine the total. This process is used to build an understanding that multiplication can be understood as the repeated addition of the same groups. The intervention is implemented in stages, taking into account the learning characteristics of students with intellectual disabilities. Instructions are given in a simple and concrete manner, demonstrations are conducted directly, and exercises are provided repeatedly. The teacher also provides *scaffolding* and feedback while students manipulate the blocks. These strategies are intended to reduce reliance on rote memorization and improve students' ability to understand the relationship between concrete quantities and multiplication symbols.

Procedure for Classroom Action

Each cycle follows four stages: planning, action, observation, and reflection.

In Cycle I, the planning stage includes developing instructional materials, providing Dienes blocks, preparing observation sheets for teachers and students, and developing an assessment instrument for multiplication skills. The instructional content focuses on understanding multiplication as repeated addition. During the action stage, the teacher introduces the concept of multiplication using Dienes blocks through demonstrations and hands-on activities. Students then group the blocks based on the given multiplication operations. Throughout the lesson, the activities of both the teacher and students are systematically observed.

The reflection phase of Cycle I was conducted after all observation data and evaluation results were analyzed. The reflection aimed to identify the effectiveness of the teaching media, the level of student engagement, the clarity of instructions, students' difficulties in manipulating the blocks, and the appropriateness of the question difficulty level relative to student ability. These findings served as the basis for refining the instructional actions in Cycle II.

In S Cycle II, the lesson plan was revised based on the results of the reflection from Cycle I. Modifications were primarily made by simplifying instructions, increasing the intensity of guidance, providing more concrete examples, and optimizing the use of Dienes blocks. The teacher provided more structured guidance to students with intellectual disabilities, then gradually reduced assistance as students demonstrated increased independence. Observations and evaluations were conducted again to identify changes in students' activities and multiplication skills. At the end of Cycle II, a comprehensive reflection was conducted by comparing the initial conditions, the results of Cycle I, and the results of Cycle II. The study was terminated once all success indicators had been met. Conversely, if the indicators had not yet been met, an action plan could be developed for the next cycle.

Data Collection

Research data were collected through observation, tests, and documentation. The use of multiple data collection techniques allowed the study to obtain information regarding changes in academic abilities as well as the learning process that took place during the intervention. Observation was used to identify teacher and student activities during Dienes Block-based learning. The observation instrument consisted of 15 items rated using a four-point Likert scale. The observation focused on students' engagement in following instructions, their manipulation of learning materials, their attention during lessons, their participation in completing tasks, their ability to follow learning steps, and their responses to the use of Dienes Blocks. Observations were also used to document the implementation of interventions and changes in students' learning behaviors during each cycle. Tests were used to measure students' ability to perform multiplication operations. Tests were administered before the intervention via a pre-test and after the intervention in each cycle via a learning evaluation. Test scores were used to obtain information regarding changes in students' multiplication skills from the initial condition to the end of the intervention. Documentation served as supporting data, including students' work samples, field notes, documentation of learning activities, and other documents relevant to the research implementation. The documentation data were used to reinforce the interpretation of the observation and test results.

Research Instruments

The research instruments consist of teacher activity observation sheets, student activity observation sheets, and multiplication proficiency tests, supplemented by documentation and field notes. The instruments were designed based on the research objectives and the proficiency indicators intended to be developed through the use of the Dienes Blocks. Observation sheets were used to monitor the consistency of intervention implementation as well as students' responses to the intervention. Multiplication proficiency tests were used to obtain quantitative data regarding the development of learning outcomes.

Meanwhile, documentation and field notes are used to record the learning context that cannot be fully represented through numerical scores. To enhance the credibility of the data, information from observations, tests, documentation, and field notes was compared during the analysis process. This approach allows researchers to triangulate process data and outcome data so that interpretations regarding the effectiveness of the intervention do not rely solely on a single data source.

Data Analysis

Data analysis employs a mixed quantitative–qualitative approach tailored to the characteristics of action research. Quantitative data are derived primarily from pre-test results and multiplication skill assessments, while qualitative data come from observations, field notes, and documentation of the learning process. Qualitative analysis is based on Miles and Huberman's interactive analysis framework, which includes data collection, data reduction, data display, and conclusion drawing and verification. During the data collection phase, all information from observations, tests, documentation, and field notes is compiled. The data is then reduced by selecting information relevant to the research focus, specifically changes in learning activities, understanding of multiplication concepts, responses to the Dienes Blocks, and obstacles encountered during the intervention. The reduced data is then presented in the form of narratives, tables, and relevant visual representations. The final stage—drawing and verifying conclusions—is conducted by comparing patterns of findings across cycles. Quantitative analysis was conducted by calculating individual scores, class average scores, the percentage of student activity, and the percentage of classical learning mastery. Changes in student ability were analyzed by comparing pretest results with evaluation results from Cycle I and Cycle II. The percentage of classical mastery was used to determine the proportion of students who achieved the minimum score based on the school's established KKTP standards.

Criteria for Success

The success of the intervention was determined based on three main indicators. First, the average student activity reached at least 75% based on observation results. Second, the average multiplication proficiency reached a minimum score of 75, in accordance with the KKTP used in the study. Third, classical learning achievement reached at least 80%, which is the proportion of students who achieved the minimum score according to the KKTP. These three indicators are used simultaneously to determine the success of the intervention. Thus, an increase in academic scores is not viewed as the sole indicator of success. The intervention is considered more meaningful if improvements in multiplication skills occur alongside increased student engagement in the learning process. This approach aligns with the characteristics of action research (PTK), which views the improvement of the learning process and the enhancement of learning outcomes as two interrelated aspects.

Ethical Considerations

The study was conducted in accordance with the principles of educational research ethics, particularly since it involved elementary school students and students with intellectual disabilities. The research was carried out in coordination with the school administration and classroom teachers. Student data were used solely for research and academic reporting purposes, while students' individual identities were anonymized in the publication to safeguard participant confidentiality and privacy. Methodologically, this design positions the Dienes Blocks not merely as a teaching aid, but as a manipulative pedagogical intervention tested through systematic action cycles. This structure enables the study to evaluate changes in multiplication skills while identifying the learning mechanisms that help students with intellectual disabilities understand mathematical concepts within an inclusive educational environment

RESULT AND DISCUSSION

Development of Students' Multiplication Skills

The classroom action research was conducted through a *pre-test*, Cycle I, and Cycle II to identify changes in students' multiplication skills following the implementation of instruction using Dienes Blocks. The analysis of learning outcomes focused on two main indicators: the mean multiplication score and the percentage of students achieving mastery at the class level. The results demonstrated a consistent pattern of improvement from the initial condition through the end of Cycle II.

Table 1. Development of Multiplication Learning Outcomes

RESEARCH STAGE	MEAN SCORE	CLASSICAL MASTERY	CHANGE IN MEAN	CHANGE IN MASTERY
PRE-TEST	72.16	66.67%	–	–
CYCLE I	75.88	79.17%	+3.72	+12.50 percentage points
CYCLE II	79.21	91.67%	+3.33	+12.50 percentage points
PRE-TEST → CYCLE II	**+7.05**	**+25.00 percentage points**	**9.77%**	**+25.00 pp**

The data in Table 1 indicate that the mean multiplication score increased from 72.16 on the pre-test to 75.88 in Cycle I, followed by a further increase to 79.21 in Cycle II. Overall, the mean score increased by 7.05 points, representing an approximately 9.77% increase compared with the initial condition. A more substantial improvement was observed in classical mastery. At the pre-test stage, the mastery rate was only 66.67%. Following the implementation of the Cycle I intervention, this percentage increased to 79.17%, representing an increase of 12.50 percentage points. However, this result had not yet reached the predetermined research success criterion of 80%. Therefore, the intervention was continued into Cycle II. After instructional improvements were implemented in Cycle II, classical mastery increased to 91.67%. Thus, there was an overall increase of 25 percentage points from the initial condition. This achievement exceeded the predetermined classical mastery criterion of 80%. The mean score also reached 79.21, exceeding the minimum Learning Objective Achievement Criterion (KKTP) of 75.

Table 2. Comparison of Achievement With the Research Success Criteria

INDICATOR	SUCCESS CRITERION	PRE-TEST	CYCLE I	CYCLE II	FINAL STATUS
MEAN MULTIPLICATION SCORE	≥75	72.16	75.88	79.21	**Achieved**
CLASSICAL MASTERY	≥80%	66.67%	79.17%	91.67%	**Achieved**
STUDENT ACTIVITY	≥75%	Not available	Not available	Not available	**Observation data needed**

Table 2 shows that the academic indicators of the study were achieved in Cycle II. The mean score increased beyond the KKTP threshold, while classical mastery reached 91.67%. Therefore, based on the two available learning-outcome indicators, the Cycle II intervention met the criteria for terminating the classroom action research. It should be noted that the minimum student activity criterion of 75% cannot yet be determined as achieved or not achieved because the percentage data from the student activity observations were not provided. For an article intended for submission to a Scopus-indexed journal, these observational data should be included so that all three research success indicators can be analyzed comprehensively.

Changes in Multiplication Skills From the Pre-test to Cycle II

Changes in learning outcomes can be analyzed through the differences in mean scores at each research stage. From the pre-test to Cycle I, the mean score increased by 3.72 points. Subsequently, from Cycle I to Cycle II, an additional increase of 3.33 points was observed. Overall, the cumulative increase from the initial condition to Cycle II was 7.05 points. These findings indicate that improvement in learning outcomes did not occur only after the initial intervention but continued following the refinement of the instructional strategy in Cycle II. This pattern is important within the context of classroom action research because intervention effectiveness is not determined solely by the introduction of instructional media but also by the process of reflection and adaptation based on difficulties identified during the preceding cycle. The increase in classical mastery was more pronounced than the increase in the mean score. Mastery increased from 66.67% to 79.17% in Cycle I and subsequently reached 91.67% in Cycle II. This finding indicates that the intervention not only improved overall class performance but also increased the proportion of students who achieved the established learning standard.

Findings From the Learning Process

Observations conducted during the intervention revealed changes in how students interacted with the multiplication content. Under the initial learning conditions, instruction relied primarily on verbal explanations, problem-solving exercises, and memorization of multiplication facts. This approach was particularly challenging for students with intellectual disabilities because multiplication concepts were presented in relatively abstract symbolic forms. During Cycle I, Dienes Blocks were introduced as a concrete representation of multiplication. The teacher guided students in forming groups of blocks based on the multiplication problems presented. For example, the operation 3 × 4 was represented as three groups, each containing four units. Through this activity, students did not merely obtain the final answer but also experienced the process through which the quantity was formed through equal groups.

Nevertheless, observations during Cycle I indicated that some students continued to experience difficulty distinguishing between the number of groups and the number of objects in each group. This difficulty indicates that the use of concrete materials does not automatically produce conceptual understanding. Students still required simplified instructions, repeated demonstrations, guided questioning, and individualized support. The results of this reflection served as the basis for modifying the intervention in Cycle II. The teacher simplified the instructions, increased the intensity of individualized support, provided examples progressively, and optimized the use of unit and tens blocks. Students were subsequently provided with more opportunities to manipulate objects, organize quantities into groups, calculate results, and connect concrete representations with multiplication symbols. During Cycle II, students demonstrated greater engagement in the learning activities. Most students were able to organize the Dienes Blocks according to the problems presented and explain the process through which they obtained their answers. This change occurred alongside improvements in both the mean score and classical mastery.

Analysis of The Research Findings

Quantitatively, the effectiveness of the intervention can be examined through the three measurement points: the initial condition, Cycle I, and Cycle II. The 7.05-point increase in the mean score from the pre-test to Cycle II indicates an improvement in students' multiplication skills following the implementation of the intervention. However, this increase should be interpreted within the context of classroom action research because the study did not employ a control group. Therefore, the findings are more appropriately interpreted as improvements observed during the classroom intervention, rather than as experimental evidence demonstrating that all observed gains were solely caused by the use of Dienes Blocks. The strongest indicator was classical mastery. The increase from 66.67% to 91.67% indicates that an increasing proportion of students achieved the established learning standard following the intervention. Moreover, the Cycle II achievement was 11.67 percentage points above the 80% target. This finding provides practical evidence that the instructional design implemented in Cycle II was more successful than the initial condition and Cycle I. Notably, the increase in the mean score from Cycle I to Cycle II was relatively smaller than the increase in classical mastery. The mean score increased by only 3.33 points, whereas classical mastery increased by 12.50

percentage points. This pattern suggests that the Cycle II intervention may have been particularly beneficial for students who had remained below the KKTP threshold during Cycle I. In other words, the subsequent intervention appears to have helped reduce the number of students who had not yet achieved the learning standard, even though the increase in the overall class mean was not as large as the change in classical mastery.

Table 3. Summary of Changes in Learning Outcomes

COMPARISON	Δ MEAN SCORE	Δ MASTERY	INTERPRETATION
PRE-TEST → CYCLE I	+3.72	+12.50 pp	The intervention began to demonstrate positive instructional effects
CYCLE I → CYCLE II	+3.33	+12.50 pp	Instructional refinements expanded learning mastery
PRE-TEST → CYCLE II	**+7.05**	**+25.00 pp**	Overall improvement following two intervention cycles

Based on the overall findings, Cycle II represents the point at which the research success criteria were achieved, as the mean score reached 79.21 and classical mastery reached 91.67%. Therefore, based on the available academic achievement indicators, no additional cycle was required.

DISCUSSION

The findings of this classroom action research indicate that the use of Dienes Blocks is associated with a gradual improvement in students' multiplication performance, from the pretest through Cycle I to Cycle II. The average score increased from 72.16 at the baseline to 75.88 in Cycle I and further to 79.21 in Cycle II, while the classical mastery rate increased from 66.67% to 79.17% and finally to 91.67%. This pattern is significant because the improvement was not limited to the class average score; the proportion of students who met the predefined learning criteria also increased significantly. The overall increase of 7.05 points in the average score and 25 percentage points in classical mastery indicates that this instructional intervention was highly beneficial for students who initially struggled to reach the expected level of multiplication proficiency. However, because this study used a classroom action research design without a control group, these findings should be interpreted as evidence of improvement during the intervention, not as definitive experimental proof that Dienes Blocks alone caused the observed improvement.

The improvements observed in this study are consistent with current evidence suggesting that mathematics instruction for students with intellectual disabilities benefits from structured, explicit, and intensively supported learning sequences. A systematic review by Schnepel and Aunio (2022), which examined mathematics interventions involving elementary school students with intellectual disabilities, found that systematic instruction, explicit instruction, feedback, and manipulatives were recurring characteristics of effective interventions. The authors emphasize that successful interventions must be structured and tailored to students' achievement levels. The findings of this study extend this evidence to the context of classroom-based inclusive education in Indonesia, where Dienes Blocks are not used as a separate teaching material but are integrated into the teacher's explanations, guided practice, student manipulation, repeated examples, and reflective modifications throughout the teaching cycle. Thus, the effectiveness observed in this study appears to stem from the interaction between concrete teaching materials and the pedagogical structure surrounding their use.

The most significant changes occurred between the pre-test and Cycle I, when the average score increased by 3.72 points and mastery of the classic method increased by 12.50 percentage points. This initial improvement can be interpreted through the representational function of Dienes Blocks. Before the intervention, multiplication was primarily presented through verbal explanations, symbolic notation, and rote memorization. Such representations may pose substantial cognitive demands for students who struggle to process abstract mathematical relationships. Dienes Blocks allow students to externalize mathematical structures by physically constructing equivalent groups. For example, the expression 3×4 can be represented as three groups, each containing four units. Consequently, multiplication transforms from an abstract symbolic expression into a visible and manipulable relationship between groups and quantities. This interpretation aligns with research showing that concrete and representational approaches can support students who struggle with mathematical concepts by linking mathematical symbols to meaningful physical or visual representations (Flores & Hinton, 2022; Zhang et al., 2022).

These findings also indicate that concrete materials should not be viewed as something that automatically leads to conceptual understanding. During Cycle I, some students were still confused about distinguishing between the number of groups and the number of objects within each group. This observation is theoretically significant because it shows that manipulating physical objects does not always guarantee mathematical abstraction. Instead, teachers must explicitly direct students' attention to the mathematical meanings represented by these objects. The teacher's mediating role aligns with evidence from CRA research, where concrete experiences are most effective when intentionally linked to visual representations and, subsequently, to mathematical symbols (Ebner et al., 2025; Milton et al., 2023). A recent meta-analysis involving 30 single-case studies found a very large overall effect for CRA mathematics interventions, supporting the importance of systematically guiding students from concrete materials toward representational and abstract mathematical forms.

The progression from Cycle I to Cycle II provides further evidence of the importance of instructional adaptation. Although the average score increased only from 75.88 to 79.21, the classical mastery rate rose from 79.17% to 91.67%. This disproportionate increase in mastery suggests that the second intervention cycle may be particularly beneficial for students who still fell below learning criteria after the first cycle. Rather than simply repeating the same learning procedures, teachers responded to difficulties identified through reflection by simplifying instructions, increasing individual guidance, providing more structured demonstrations, and optimizing the use of unit and ten blocks. This adaptive process aligns with the principles of evidence-based learning identified by

Bouck and Long (2023), which emphasize the importance of identifying instructional practices that align with the learning characteristics of students with mild intellectual disabilities.

The role of manipulatives in this study is also supported by research involving students with intellectual and developmental disabilities. Jimenez and Besaw (2020), for example, demonstrated that manipulative-supported instruction can facilitate the development of early numeracy skills in students with autism and moderate intellectual disabilities. Although their study used virtual manipulatives rather than physical ones, the underlying teaching principle remains relevant: mathematical concepts become easier to understand when students can interact with representations of quantities and relationships, rather than relying solely on abstract symbolic notation. Similarly, Long et al. (2023) concluded from a synthesis of evidence-based practices that manipulative-based approaches are an important instructional resource for mathematics learning involving students with autism as well as intellectual and developmental disabilities. Therefore, this study provides an important complementary perspective by demonstrating the potential value of physical Dienes Blocks in inclusive elementary classrooms, rather than relying solely on digital or virtual manipulatives.

This improvement in multiplication proficiency is noteworthy because multiplication represents a transition from simple counting and addition to more complex multiplicative reasoning. Students who primarily rely on rote memorization may be able to produce correct answers under familiar conditions but struggle when numerical relationships are presented in unfamiliar forms. Dienes Blocks provide an opportunity to represent multiplication as repeated equal groupings, thereby allowing students to build conceptual connections between multiplication and repeated addition before relying on symbolic procedures. These findings align with the research by Bouck et al. (2020), which demonstrates the value of a sequence of aid-based learning, explicit instruction, repeated practice, and gradual reduction of support when teaching multiplication and division to students with developmental disabilities. Their findings are highly relevant because the mathematical content addressed includes multiplication and division, even though their intervention utilized virtual tools and involved a population of middle school students.

The current findings are also consistent with research showing that explicit instructional structures can lead to significant improvements in arithmetic performance among students with intellectual disabilities. Schöld et al. (2023/2024) conducted a randomized controlled trial involving 30 students with mild intellectual disabilities and reported significant improvements in arithmetic fact fluency following an explicit instruction-based intervention; importantly, these effects were maintained at the six-month follow-up. Although this study did not evaluate retention, its findings suggest that a combination of explicit teacher guidance and concrete representations can support the initial mastery of multiplication skills. Therefore, future research should investigate whether the improvements observed after Cycle II remain stable as the Dienes blocks are gradually phased out.

These findings can be further understood through the CRA framework. In the concrete phase, students manipulate Dienes blocks to form equivalent groups. In the representational phase, these groups can be transformed into images or visual arrangements, whereas in the abstract phase, students can connect these representations to multiplication equations. Although this classroom action research primarily emphasized the concrete phase, the learning process implicitly fostered a transition toward the representational and abstract phases. Research by Zhang et al. (2022) shows that CRA instruction improves mathematics achievement among elementary school students with math learning disabilities, while Flores and Hinton (2022) report that explicit CRA instruction can support mathematics learning outcomes among elementary school students with emotional and behavioral difficulties. The alignment between these findings and the results of this study reinforces the interpretation that the progression from the concrete to the symbolic is particularly beneficial when mathematical concepts are initially difficult to grasp through abstract notation.

The results of this study are also consistent with recent evidence regarding CRA-based instruction for students with disabilities. Kaya and Guner Yildiz (2024) reported that the CRA sequence, combined with explicit instruction, successfully supported the mastery of mathematical skills for a student with autism in a general education classroom. The intervention focused on basic addition, subtraction, and the concepts of tens and ones, and the skills acquired were maintained after the intervention ended. Similarly, Nara and Batu (2024) investigated CRA instruction for students with mild intellectual disabilities and reported evidence of its effectiveness in teaching basic addition facts. Goñi-Cervera et al. (2024) also found a functional relationship between CRA instruction and mastery of cardinality among preschoolers with autism, accompanied by evidence of retention and generalization. Collectively, these studies demonstrate that the value of teaching from concrete to representational is not limited to a single domain of mathematics or a single category of disability.

A key contribution of this study is the demonstration that Dienes Blocks can serve as a bridge between conceptual understanding and procedural performance. During the baseline phase, students tended to rely on memorized multiplication facts. After the intervention, they increasingly formed groups, counted quantities, and explained how answers were derived. These behavioral changes indicate a shift from answer-oriented performance toward process-oriented understanding. Such a transition holds significant educational implications because mathematical competence involves not only obtaining the correct answer but also understanding relationships between quantities and being able to communicate the reasoning underlying a solution. Hord (2023), for example, emphasizes the value of manipulatives, diagrams, movement, and connections to students’ experiences when teaching mathematics to students with mild intellectual disabilities.

These findings are also consistent with research showing that manipulatives can be integrated into broader learning sequences, rather than merely serving as supplementary teaching aids. Bouck et al. (2023) demonstrate that a virtual number line intervention, combined with teacher modeling and systematic guidance, can support the mastery of mathematical skills among students with intellectual disabilities. Similarly, Root et al. (2022) demonstrated the potential of structured mathematics instruction implemented by teachers for students with autism and intellectual disabilities. These findings support the interpretation that the effectiveness of Dienes Blocks in this study was likely enhanced by teacher modeling, guided practice, repetition, feedback, and a gradual increase in task complexity.

Evidence from elementary education in Indonesia further supports the practical relevance of these findings. Muin et al. (2024) reported that the implementation of Dienes Blocks in a two-cycle classroom action research study improved mathematics learning outcomes among first-grade elementary school students. The study found that student learning outcomes improved from the first cycle to the second cycle following the use of Dienes Blocks. Legi (2021) also reported that Dienes Blocks can enhance students' understanding of integer addition and facilitate the transition from the enactive stage to the iconic and symbolic stages in mathematics learning. Herzamzam et al. (2024) also documented the use of Dienes Blocks as a concrete learning medium in elementary school mathematics education. These studies in Indonesia are significant because they demonstrate that Dienes Blocks can be applied in the context of local elementary schools. This study expands upon that literature by focusing specifically on multiplication skills among students with intellectual disabilities in inclusive classrooms.

However, the quantitative findings in this study should be interpreted with caution. The increase in the average score from 72.16 to 79.21 represents a relative increase of 9.77%, while mastery increased by 25 percentage points. More significant changes in mastery suggest that the intervention may be highly effective in moving students who are close to the learning threshold into the mastery category. This distinction is important because a moderate increase in the class average can occur alongside a substantial decrease in the number of students who remain below the required standard. Therefore, the educational significance of this intervention cannot be adequately represented by average scores alone. An increase in the proportion of students meeting the criteria provides an additional indicator of instructional effectiveness.

The Cycle II result of 91.67% in classical mastery also has implications for inclusive education. The goal of an inclusive classroom is not merely to place students with disabilities alongside their peers, but to provide learning conditions that enable a diverse student body to participate meaningfully in academic activities. The use of the same concrete mathematical representations can facilitate shared participation because students can manipulate the same materials while receiving differentiated levels of teacher support. In this regard, Dienes blocks can serve not only as a mathematical medium but also as an inclusive pedagogical resource. This interpretation aligns with contemporary research emphasizing the importance of accessible and differentiated learning approaches for students with disabilities in general education settings.

At the same time, these findings caution against attributing the observed improvements solely to the physical characteristics of Dienes Blocks. The intervention included several components implemented simultaneously: teacher explanation, modeling, repeated practice, guided questioning, individual support, concrete manipulation, reflection, and learning refinement. Therefore, this intervention should be understood as a structured teaching approach supported by Dienes Blocks, rather than as an isolated effect of the instructional material itself. This distinction aligns with the literature indicating that manipulatives are most effective when integrated into a systematic and explicit instructional sequence (Schnepel & Aunio, 2022; Bouck & Long, 2023).

Another important consideration relates to the absence of a control group and the relatively short intervention period. Since this study employed classroom action research, the observed improvements may have been influenced by repeated exposure to the test format, increased familiarity with multiplication tasks, teacher attention, or cumulative teaching practices. Therefore, these findings provide a strong practical foundation for continuing the use of Dienes Blocks in the observed classroom, but do not offer the same level of causal inference as a randomized controlled trial. Future research could address these limitations through single-case experimental designs, quasi-experimental comparisons, or randomized controlled studies involving a larger sample of students with intellectual disabilities. Such research could also analyze delayed post-intervention tests to determine whether students retain multiplication skills after the concrete materials are removed. Overall, these findings suggest that Dienes Blocks can provide a meaningful concrete foundation for teaching multiplication when combined with explicit explanations, guided practice, repeated opportunities for manipulation, and differentiated teacher support.

An increase in the mean score from 72.16 to 79.21 and an increase in the classical mastery rate from 66.67% to 91.67% indicate substantial improvement over the two intervention cycles. These results are generally consistent with current evidence supporting the use of manipulatives, explicit instruction, and CRA-based approaches for mathematics learning among students with disabilities. More importantly, this study demonstrates that the transition from abstract memorization to concrete grouping and visual representation can make multiplication easier to understand for students with intellectual disabilities in inclusive elementary school classrooms. Therefore, the primary pedagogical implication is not merely that teachers should “use Dienes blocks,” but rather that concrete materials must be intentionally incorporated into a structured instructional sequence that connects physical manipulation, mathematical representation, verbal reasoning, and symbolic notation.

CONCLUSION

This classroom action research shows that the use of Dienes Blocks can support the improvement of multiplication skills among fifth-grade students in an inclusive elementary school, particularly students with intellectual disabilities. The intervention, implemented over two cycles, resulted in consistent improvements in student learning outcomes. The average score increased from 72.16 on the pretest to 75.88 in Cycle I and further to 79.21 in Cycle II. Similarly, the mastery rate increased from 66.67% at the baseline to 79.17% in Cycle I and 91.67% in Cycle II, exceeding the previously established criterion of 80%. These findings indicate that the intervention was associated with significant improvements in both average achievement and the proportion of students meeting the learning criteria. Further classroom observations showed that Dienes Blocks facilitated students' understanding by transforming multiplication from an abstract symbolic operation into a concrete grouping activity. Students were able to manipulate, organize, count, and relate groups of objects to multiplication expressions. Difficulties observed during Cycle I—particularly in distinguishing the number of groups from the number of objects in each group—were addressed through simplified instructions, repeated demonstrations, and more intensive teacher guidance in Cycle II. Thus, these findings suggest that the effectiveness of Dienes Blocks is enhanced when combined with systematic scaffolding and reflective instructional improvements. However, since this study employed a classroom action research design without a control group, these improvements cannot be interpreted as definitive causal evidence entirely attributable to Dienes Blocks. Furthermore, the available data do not include the percentage of student activities required by the predefined success criteria. Therefore, future research should incorporate more comprehensive observational measures and a comparative design to further examine the effectiveness and generalizability of Dienes Blocks in inclusive mathematics instruction.

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