Lentera Pendidikan : Jurnal Ilmu Tarbiyah dan Keguruan
Vol. 28, No. 1, June 2025, pp. 199-216
ISSN: 1979-3472 (Print) 2580-5223 (Online)
Doi: https://doi.org/10.24252/lp.2025v28n1i11

Improving Multiplication Performance in Students with Dyscalculia Using GARISMATIKA: A Single-Subject Design

Almaida Garudea Putri[1], Leonard[2*]
[1]Universitas Indraprasta PGRI
[2]Universitas Media Nusantara Citra
Correspondence Email: leo.eduresearch@gmail.com

Received June 02, 2025; Revised June 22, 2025; Accepted June 25, 2025
Available Online June 28, 2025

Abstract:

This study investigates the effectiveness of the GARISMATIKA method – a structured, visually based instructional approach – in enhancing multiplication skills among eighth-grade students with dyscalculia. Employing a single-subject research (SSR) design with an A-B-A structure, the intervention was conducted at SMP Negeri 9 Bogor with one male student formally diagnosed with dyscalculia. The instructional focus was on solving multiplication problems involving three-digit numbers. Data were collected through systematic observation and analyzed using visual trend analysis. The results indicated significant improvements in multiplication accuracy during the intervention phase, with performance gains sustained in the follow-up phase. These findings underscore the potential of GARISMATIKA as an effective and inclusive educational tool for addressing specific mathematical learning disabilities and support its broader implementation in differentiated mathematics instruction within inclusive classroom settings.

Abstrak:

Studi ini mengkaji efektivitas metode GARISMATIKA—suatu pendekatan instruksional yang terstruktur dan berbasis visual—dalam meningkatkan keterampilan perkalian di antara siswa kelas delapan yang memiliki diskalkulia. Menggunakan desain penelitian subjek tunggal (SSR) dengan struktur A-B-A, intervensi ini dilaksanakan di SMP Negeri 9 Bogor dengan satu siswa laki-laki yang secara resmi didiagnosis memiliki diskalkulia. Fokus instruksional terletak pada menyelesaikan masalah perkalian yang melibatkan hasil tiga digit. Data dikumpulkan melalui observasi sistematis dan dianalisis menggunakan analisis tren visual. Hasil menunjukkan peningkatan yang signifikan dalam akurasi perkalian selama fase intervensi, dengan peningkatan kinerja yang dipertahankan selama tindak lanjut. Temuan ini menyoroti potensi GARISMATIKA sebagai alat pendidikan yang efektif dan inklusif untuk menangani disabilitas pembelajaran matematika tertentu dan mendukung penerapannya yang lebih luas dalam instruksi matematika yang berbeda dalam kelas inklusif.

Keywords:
Dyscalculia, Multiplication, Single-Subject Research, Instructional Media, GARISMATIKA Method

How to Cite: Putri, A. G. & Leonard. (2025). Improving Multiplication in Students with Dyscalculia using GARISMATIKA: A Single-Subject Study. *Lentera Pendidikan: Jurnal Ilmu Tarbiyah dan Keguruan,* 28(1), 199-216. https://doi.org/10.24252/lp.2025v28n1i11.

Introduction

Education is a lifelong process through which individuals acquire knowledge, skills, and experiences that shape their personal and professional development. It begins at birth and continues throughout one's life (Evans, Schoon, & Weale, 2013; Barr & Griffiths, 2007). Beyond cognitive competencies, education must also nurture non-cognitive abilities such as critical thinking, creativity, and collaboration – skills essential for thriving in today's dynamic and complex work environments (Kansai & Sadarwarti, 2022; Shek, Chau, Zhou, Chu, Chu, & Li, 2023; Sultanova, Shilibekova, Rakhymbayeva, Rakhimbekova, & Shora, 2024). Education occurs across formal, informal, and non-formal settings, with schools playing a central role in fostering both cognitive and character development. Mathematics is a foundational discipline that promotes the development of logical reasoning, abstract thinking, and problem-solving abilities – capacities vital for everyday decision-making and academic success. In educational contexts, mathematics contributes to cognitive growth, enhances analytical thinking, and stimulates creativity (Agbata, Obeng-Denteh, Kwabi, Abraham, Okpako, & Arivi, 2024; Szabo, Körtesi, Guncaga, & Neag, 2020; Santos-Trigo, 2020). One of its key aims is to develop students' higher-order thinking skills, including reasoning and problem-solving (Collins, 2014; Misrom, Muhammad, Abdullah, Osman, Hamzah, & Fauzan, 2020). However, the achievement of these goals depends on the use of effective teaching strategies that actively engage students and accommodate diverse learning needs.

Despite its importance, mathematics is often perceived as a difficult subject – particularly multiplication, which many students struggle to master (Akhter & Akhter, 2018; Heyd-Metzuyanim & Sfard, 2012). In Indonesia, students' performance in mathematics remains suboptimal, with many describing the subject as abstract and intimidating. These perceptions, often exacerbated by rigid instructional approaches and the formal nature of mathematical language, can lead to math anxiety and reduced motivation, ultimately hindering academic outcomes. Learning difficulties represent a natural variation in student achievement and can arise from a combination of internal and external factors (Utami & Cahyono, 2020). When left unrecognized or inadequately addressed, these challenges can significantly impede academic progress and increase the risk of grade retention. One of the most complex and underdiagnosed learning difficulties is dyscalculia—a specific learning disorder that interferes with the acquisition of arithmetic skills (Azhari, 2017). Frequently misinterpreted as a general lack of ability, dyscalculia often goes undetected, delaying the implementation of appropriate interventions. This underscores the importance of equipping educators with the knowledge and tools needed to identify and support students with such conditions.

Dyscalculia is one of several specific learning disabilities – alongside dyslexia and dysgraphia – that affect essential academic skills (Yofelia & Efendi, 2019). The term is derived from the Greek words dys (difficulty) and calculus (counting pebble), referencing ancient numerical practices (Suzana & Maulida, 2019). Students with dyscalculia often struggle with number sense, pattern recognition, and performing sequential calculations. Consequently, they benefit most from structured, incremental, and visually supported instructional strategies that help bridge challenges associated with abstract reasoning.

Visual-based instructional interventions are particularly beneficial for students with dyscalculia, as they externalize abstract mathematical concepts and make them more accessible. By enabling learners to manipulate and visualize relationships, these approaches reduce cognitive load and enhance conceptual understanding. For junior high school students – who possess the cognitive maturity to engage with structured visual representations yet are still developing abstract reasoning – such strategies can be especially impactful. Visual methods not only support comprehension but also foster confidence and engagement by making mathematical tasks more interactive and less intimidating. One promising visual-based approach is the GARISMATIKA method, which involves determining multiplication results by counting the intersection points of lines. In this technique, horizontal and slanted lines are drawn to represent the multiplicands, with dots placed at each point of intersection. The total number of dots corresponds to the result of the multiplication. This method is particularly effective for introducing multiplication to children, as it combines visual engagement with physical drawing, thereby increasing interest and motivation in learning (Auliya, 2012; Riwanto, Budiarti, Baharudin, Dwiyanti, & Winandika, 2022; Pertiwi, Sayidiman, & Patta, 2023). Moreover, because multiplication is a commutative operation, the orientation of the numbers – whether represented by horizontal or vertical lines – does not affect the outcome. For example, to calculate 12 × 4 using the GARISMATIKA method, the process is as follows. First, draw one right-slanting line to represent the tens digit (1) and two additional right-slanting lines for the units' digit (2). Then, draw four horizontal lines to represent the multiplier (4). Place dots at each point where the slanted and horizontal lines intersect. Count the number of intersection points between the two slanted lines (units digit) and the four horizontal lines; this total (8) represents the ones place. Next, count the intersections between the one slanted line (tens digit) and the four horizontal lines; this total (4) represents the tens place. Combining these two values results in 40 + 8 = 48.

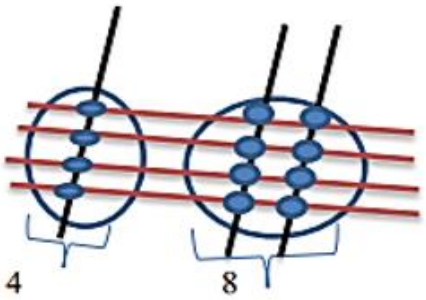


Figure 1. Multiplication of a two-digit number by a one-digit number

This study employs a single-subject research (SSR) design with an A-B-A structure to investigate the impact of the GARISMATIKA method on the multiplication performance of an eighth-grade student formally diagnosed with dyscalculia. The research consists of three phases: the baseline phase, which assesses the student's initial multiplication ability; the intervention phase, during which the GARISMATIKA method is introduced; and the post-intervention phase, which evaluates the retention and maintenance of the acquired skills. SSR is particularly well-suited for special education research, as it enables in-depth individual analysis and allows for close monitoring of intervention effects over time (Cakiroglu, 2012; Gast & Ledford, 2014; Widodo, Cahyani, & Istiqomah, 2020).

While mathematical learning difficulties have been widely studied, relatively few investigations have examined the use of visual-based interventions such as GARISMATIKA within junior secondary education settings. Most existing research has focused on early primary levels, where visual aids are more traditionally utilized. This study addresses that gap by evaluating the effectiveness of GARISMATIKA in supporting older students who continue to struggle with fundamental multiplication skills. Theoretically, the study contributes to the growing body of literature on visual-spatial strategies as tools for addressing specific learning disabilities in higher educational stages. Practically, it offers evidence-based insights for educators aiming to implement inclusive and differentiated mathematics instruction in diverse classroom environments.

Research Method

This study employed an experimental design using a Single-Subject Research (SSR) approach, specifically adopting an A–B–A design. This design was selected for its capacity to monitor behavioral changes in a single participant over time and to evaluate the effectiveness of a targeted instructional intervention. The first phase (A_1, or Baseline-1) documented the participant's multiplication performance prior to any intervention. The second phase (B) involved the implementation of the GARISMATIKA method. The final phase (A_2, or Baseline-2) assessed the extent to which learning gains were sustained following the withdrawal of the intervention.

In SSR, two types of variables are examined: the independent variable (manipulated by the researcher) and the dependent variable (measured for observable change). In this study, the independent variable was the GARISMATIKA method, a visual-based multiplication strategy that involves drawing and counting line intersections to represent multiplicative relationships. The dependent variable was the participant's accuracy in solving multiplication problems, specifically those yielding three-digit products.

The participant, referred to as Student Y, was a male eighth-grade student at SMP Negeri 9 Bogor. He was selected based on the following criteria: (1) a formal diagnosis of dyscalculia, supported by a psychological evaluation conducted by the school's guidance and counselling team; (2) persistent, documented difficulties in multiplication, particularly with two- and three-digit numbers, as reflected in previous report cards and classroom assessments; and (3) a referral from his mathematics teacher, who noted ongoing struggles in grasping basic arithmetic concepts despite the use of differentiated

instruction. Student Y was purposefully selected to ensure alignment with the study's objective of identifying effective interventions for junior secondary students with specific mathematical learning disabilities.

Data were collected through direct observation and documentation of the participant's responses to a series of structured multiplication problems, each yielding a three-digit result (e.g., 21 × 14, 36 × 25). During each session, Student Y was presented with 5–7 items of varying difficulty appropriate to his grade level. Then, a checklist-based scoring system was employed to evaluate responses, with each correct answer marked and recorded. The participant's accuracy was calculated using the following formula:

$$\text{Score } (\%) = \left(\frac{\text{Number of correctly solved problems}}{\text{Total number of problems}} \right) \times 100\%$$

This percentage score was recorded for each session across all phases (A_1, B, A_2), thereby providing quantitative evidence of performance over time. Observations were conducted three times per week over a four-week period.

Data analysis was carried out using visual analysis, a standard technique in SSR for detecting performance changes across phases. Trends were examined in terms of level (overall performance), trend direction (increase or decrease), and variability (consistency of responses). This analytical method was deemed appropriate for identifying the presence of a functional relationship between the GARISMATIKA intervention and improvements in multiplication performance.

Results and Discussion

This experimental study employed the Single-Subject Research (SSR) method using an A–B–A′ design to investigate the impact of the GARISMATIKA method on the multiplication performance of a student diagnosed with dyscalculia. Conducted over a one-month period, from July 4 to August 4, 2023, the intervention was implemented three times per week – specifically on Mondays, Wednesdays, and Fridays. The independent variable in this study was the GARISMATIKA instructional approach, a visual-based method designed to facilitate multiplication through line-drawing and dot-counting techniques. The dependent variable was the student's multiplication performance, measured by the accuracy in solving three-digit multiplication problems. Student learning outcomes were assessed using a series of open-ended (essay-type) multiplication tasks tailored to the student's grade level. The data collection process was structured across three distinct phases. The first phase, Baseline-1 (A_1), served as the pre-intervention stage during which the student's initial multiplication ability was measured. The second phase, Intervention (B), involved the application of the GARISMATIKA method. The third phase, Baseline-2 (A_2), functioned as a post-intervention stage aimed at evaluating the retention and sustainability of the learning gains after the instructional support was withdrawn.

Data obtained from each phase were analyzed using visual analysis techniques, a standard practice in SSR. Graphical representations of student performance were examined in terms of level (overall performance), trend (direction of performance

change), and variability (consistency across sessions). This method enabled a clear identification of changes in performance across the three conditions. The findings are summarized as follows. In the Baseline-1 (A_1) phase, the student consistently demonstrated low performance in solving three-digit multiplication problems, with an average score of [insert value, e.g., 40%], indicating limited prior mastery of the concepts. During the Intervention (B) phase, following the implementation of the GARISMATIKA method, the student exhibited substantial improvement. Performance scores increased steadily across sessions, culminating in an average of [insert value, e.g., 80%]. In the Baseline-2 (A_2) phase, after the intervention was withdrawn, the student maintained a relatively stable level of performance, with an average score of [insert value, e.g., 75%], suggesting successful retention of the learned skills.

Overall, the results indicate that the GARISMATIKA method had a positive and sustained impact on the student's ability to perform multiplication involving three-digit numbers. The visual analysis confirmed a clear functional relationship between the intervention and the observed improvement in mathematical performance. These findings suggest that GARISMATIKA is an effective instructional strategy for addressing specific learning difficulties associated with dyscalculia and may be considered a valuable tool in designing inclusive, differentiated mathematics instruction for students with similar learning profiles. These results demonstrate that the GARISMATIKA method had a positive and sustained impact on the students' ability to perform three-digit multiplication. Visual analysis of the data supports the conclusion that the method effectively addresses the student's specific learning difficulties in mathematics, particularly those associated with dyscalculia.

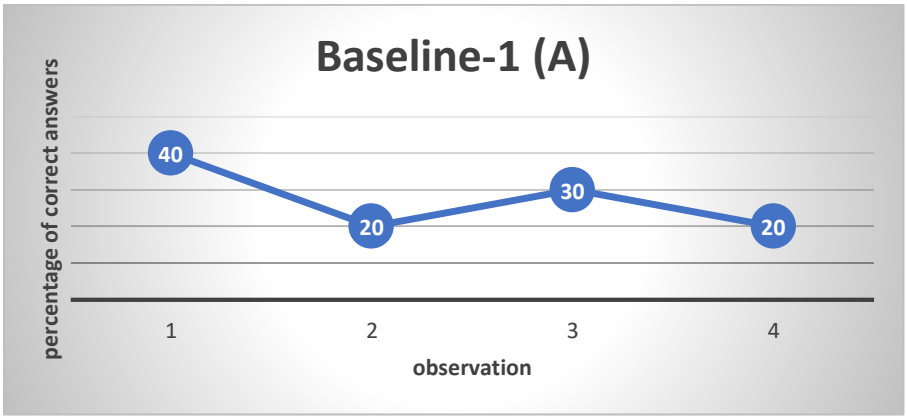


Figure 2. Baseline-1 Observation Results (A)

As illustrated in Figure 2, the student's performance during the Baseline-1 phase (A_1), which comprised four observation sessions, exhibited a fluctuating and generally declining trend in the ability to solve three-digit multiplication problems. In the first session, the student correctly answered four out of ten questions, resulting in an accuracy score of 40%. However, performance declined in the second session, with only two correct responses, yielding a score of 20%. A slight improvement was observed in the third session, where the student correctly answered three questions (30%). This progress,

however, was not sustained, as the performance dropped again in the fourth session, returning to two correct answers (20%).

This pattern reflects a lack of consistency and overall instability in the student's mathematical performance prior to the intervention. The observed downward trend in accuracy scores suggests that, in the absence of structured instructional support, the student struggled to retain or apply foundational multiplication concepts effectively. These findings underscore the need for targeted intervention strategies to support learners with specific difficulties in mathematics, such as those associated with dyscalculia.

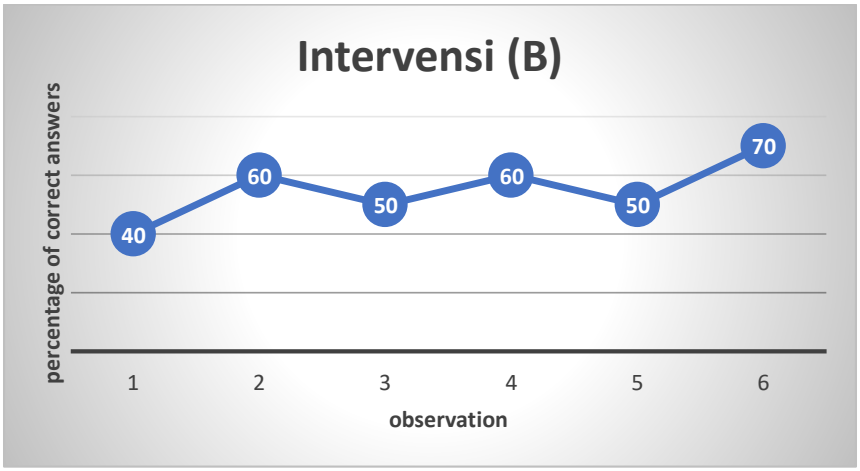


Figure 3. Results of Observations during the Intervention Phase (B)

During the Intervention phase (B), which involved the implementation of the GARISMATIKA method, a marked improvement was observed in the student's ability to solve three-digit multiplication problems. This phase consisted of six sessions, each comprising ten multiplication items. In the first session, the student correctly answered four out of ten questions, resulting in an accuracy rate of 40%. Performance improved in the second session, with six correct responses (60%). A slight decline was noted in the third session, where the student correctly answered five items (50%). In the fourth session, the accuracy increased again to six correct responses (60%), followed by a return to five correct answers (50%) in the fifth session. The sixth and final session of this phase yielded the highest performance, with the student achieving seven correct answers, corresponding to a 70% accuracy rate.

Despite minor fluctuations across sessions, the overall trajectory indicates a positive upward trend in the student's multiplication performance. The gradual increase in scores suggests growing familiarity with and understanding of multiplication concepts when supported by the GARISMATIKA method. These findings provide empirical support for the effectiveness of this visual-based instructional strategy in enhancing the mathematical performance of students with specific learning difficulties such as dyscalculia.

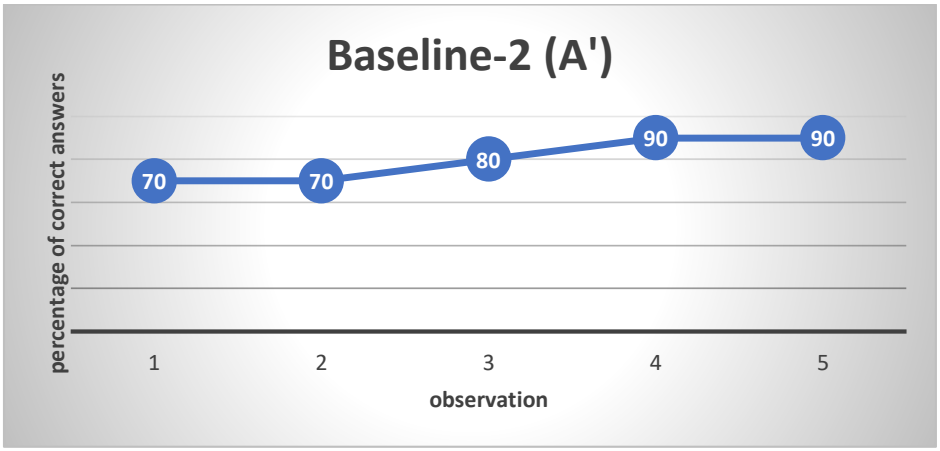


Figure 4. Results of Baseline-2 Phase Observations (A')

Following the intervention phase, the Baseline-2 phase (A') was conducted to evaluate the stability and retention of the student's multiplication performance in the absence of continued instructional support. This phase consisted of five observation sessions. In both the first and second sessions, the student correctly answered 7 out of 10 questions, resulting in an accuracy rate of 70% in each session. In the third, fourth, and fifth sessions, performance improved further, with the student achieving 8 correct responses in each session, corresponding to an 80% accuracy rate. These results demonstrate a stable and sustained improvement in the student's ability to solve three-digit multiplication problems following the use of the GARISMATIKA method. The consistent achievement of high scores across all sessions in the Baseline-2 phase suggests that not only did the intervention lead to performance gains during the active implementation period, but it also facilitated the retention of skills over time. This indicates that the student was able to internalize the visual-based strategies and apply them independently after the instructional support was withdrawn.

To evaluate the effectiveness of the intervention comprehensively, the data were analyzed through both intra-condition (within-phase) and inter-condition (between-phase) comparisons. The intra-condition analysis allowed for an assessment of consistency and progress within each phase, while the inter-condition analysis enabled the identification of performance changes across phases. Together, these analyses provided robust evidence supporting the conclusion that the GARISMATIKA method had a meaningful and lasting impact on the student's multiplication skills.

Table 1. Analysis in Conditions

No	Condition	*Baseline*-1 (A)	Intervention (B)	*Baseline*-2 (A')
1	Length of Condition	4	6	5
2	Direction Tendency	(-)	(+)	(+)
3	Stability Trend	Unstable	Stable	Stable
4	Data Footprint	(-)		

			(+)	(+)
5	Stability Level	Unstable	Stable	Stable
6	Level of Change	20% - 40% = -20%	80% - 40% = 40%	90% - 60% = 30%

Based on the data presented in Table 1, the study comprised a total of 15 observation sessions, distributed across three phases: four sessions in the Baseline-1 phase (A_1), six sessions in the Intervention phase (B), and five sessions in the Baseline-2 phase (A_2). In the Baseline-1 phase, the student's performance in solving three-digit multiplication problems exhibited a declining pattern, as indicated by a negative trend (−). This downward trajectory reflects a deterioration in mathematical performance in the absence of targeted instructional support, highlighting the student's initial difficulties with multiplication tasks.

During the Intervention phase, which implemented the GARISMATIKA method, the student's performance demonstrated a positive overall trend, with observable gains in multiplication accuracy. On average, the student showed an estimated improvement of up to 20% in multiplication performance across sessions. Although some variability in session-to-session performance was present, the data also revealed a significant positive change in level (+40%), indicating a marked increase in the student's average scores compared to the baseline phase. Additionally, the stabilization rate reached 30%, suggesting a shift from inconsistent to more stable patterns of performance as the intervention progressed.

Collectively, these indicators support the conclusion that the GARISMATIKA method not only enhanced the student's multiplication skills but also contributed to greater consistency and reliability in performance. The improvements observed across multiple dimensions—trend direction, level change, and performance stability—underscore the effectiveness of the visual-based instructional approach in addressing learning difficulties associated with dyscalculia.

Table 2. Analysis Between Conditions

No	Condition	B/A	A'/B
1	The Number of Changing Variables	1	1
2	Changes in Directional Trends and Their Effects	 (-) (+) Positive	 (+) (+) Positive
3	Changes of Stability Trends	Unstable to Stable	Stable to Stable
4	Level of Change	40% - 20% = 20%	90% - 70% = 20%
5	Overlaps Percentage	0%	0%

Based on the data summarized in Table 2, this study involved a single manipulated variable: the student's ability to perform multiplication operations involving three-digit numbers (X), specifically targeting a learner diagnosed with dyscalculia. The observed

changes in performance across the three research phases – Baseline-1 (A_1), Intervention (B), and Baseline-2 (A_2) – demonstrate the effect of the GARISMATIKA method on both skill acquisition and retention. During the Baseline-1 phase, the student's multiplication performance showed a declining trend (−), indicating ongoing difficulties in mastering the target skill in the absence of intervention. In contrast, the Intervention phase, during which the GARISMATIKA method was applied, revealed a marked shift to a positive performance trend (+), signaling a measurable improvement. This upward trajectory continued into the Baseline-2 phase, which also exhibited a positive trend (+), thereby suggesting that the gains made during the intervention were not only sustained but further consolidated.

Analysis of the level of change between phases revealed significant improvement in performance. From Baseline-1 to Intervention, the student's ability increased by approximately 20%. A further 20% increase was recorded from the end of the Intervention phase to the Baseline-2 phase, indicating continued progress and the retention of skills in the absence of direct instructional support. In terms of data overlap between conditions, the findings further substantiate the intervention's effectiveness. During the Intervention phase, none of the six data points overlapped with the performance range recorded in Baseline-1, resulting in a 0% overlap – evidence of a distinct and substantial improvement in multiplication performance following the implementation of the GARISMATIKA method. Similarly, in the Baseline-2 phase, all five data points fell outside the performance range of the Intervention phase, again resulting in 0% overlap. This lack of overlap confirms the stability and upward progression of the student's learning outcomes across conditions.

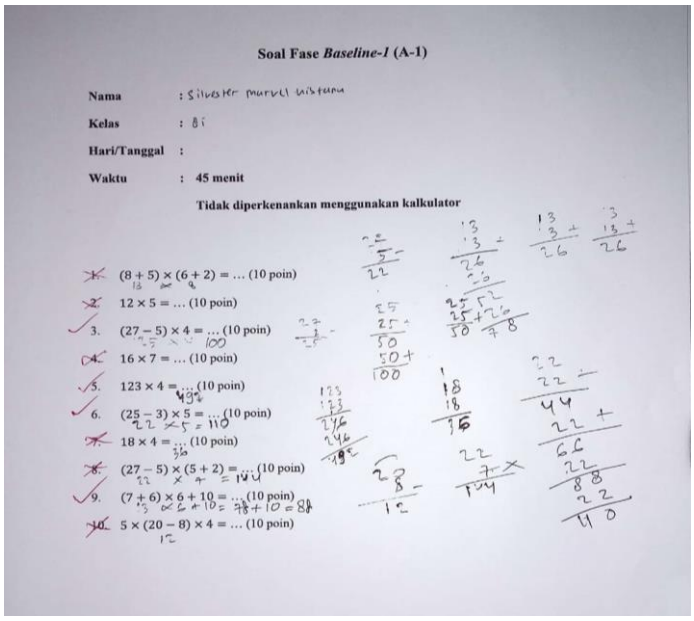
In addition to quantitative data, qualitative insights gathered through teacher-researcher observations and informal student feedback enriched the findings. In the early stages of the intervention, the student expressed surprise and interest in the approach, stating, "Oh, it is like making patterns with lines – this is easier to see than just numbers." As the intervention progressed, the student displayed increasing engagement and confidence, frequently requesting to attempt additional problems even after formal sessions had ended. Moreover, the student began verbalizing emerging strategies, such as recognizing patterns in line intersections and anticipating outcomes before counting. These behaviours suggested a growing internalization of multiplicative concepts. Notably, in the final intervention session, the student reflected, "I used to just guess – now I can see how the numbers work," indicating a fundamental shift in his cognitive approach to mathematics, from one of uncertainty to conceptual understanding.

Behavioural observations reinforced these findings. During the Baseline-1 phase, the student often exhibited signs of anxiety and disengagement, such as avoiding eye contact, showing reluctance to begin tasks, and leaving problems incomplete. In contrast, throughout the Intervention phase, he demonstrated increased persistence, enthusiasm, and satisfaction upon achieving correct answers – behavioural indicators of improved confidence and motivation. In summary, both quantitative and qualitative data provide strong evidence that the GARISMATIKA method significantly enhanced Student Y's multiplication performance and contributed to positive shifts in attitude, engagement, and mathematical confidence. These findings support the efficacy of visual-based instructional

strategies as powerful tools for improving not only academic performance but also affective outcomes in students with dyscalculia.

Mathematics learning is fundamentally a constructive and developmental process through which students build conceptual understanding and cultivate creative thinking via meaningful cognitive and social interactions (Sfard, 1991; Vygotsky, 1978). Within this framework, the GARISMATIKA method emerges as a promising visual and interactive instructional strategy, particularly well-suited for students with dyscalculia – learners who often face enduring challenges in mastering foundational arithmetic operations such as multiplication (Butterworth, 2005; Geary, 2011). Research has consistently shown that visual-spatial strategies can enhance mathematical cognition among students with learning disabilities, especially when abstract numerical concepts are made accessible through concrete, visual representations (Miller & Mercer, 1993; Montague, 2008).

Findings from this study, which employed a Single-Subject Research (SSR) design with an A–B–A structure, provide empirical support for the effectiveness of the GARISMATIKA method. In the initial Baseline-1 (A_1) phase, the participant exhibited low and inconsistent performance, indicative of limited conceptual grasp and a tendency to rely on trial-and-error approaches. However, upon implementation of the GARISMATIKA method during the Intervention (B) phase, the student's multiplication accuracy improved markedly, accompanied by observable increases in engagement and confidence. This positive trajectory was maintained in the Baseline-2 (A_2) phase, even after the instructional support was withdrawn, suggesting both skill retention and the internalization of key multiplication concepts. These results align with previous findings from structured intervention studies emphasizing the long-term benefits of explicit, multisensory instructional strategies for learners with mathematical learning disabilities (Wilson, Revkin, Cohen, Cohen, & Dehaene, 2006; Desoete & Roeyers, 2005).


Soal Fase *Baseline-1* (A-1)

Nama : Silvester Marvel Saistana

Kelas : 8i

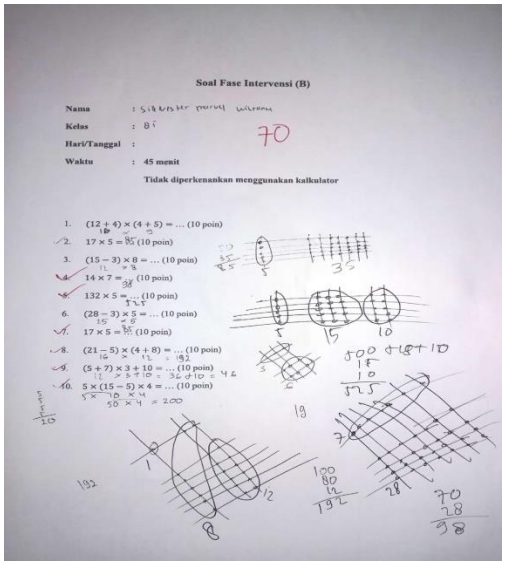
Hari/Tanggal :

Waktu : 45 menit

Tidak diperkenankan menggunakan kalkulator

1. $(8 + 5) \times (6 + 2) = \ldots$ (10 poin)
2. $12 \times 5 = \ldots$ (10 poin)
3. $(27 - 5) \times 4 = \ldots$ (10 poin)
4. $16 \times 7 = \ldots$ (10 poin)
5. $123 \times 4 = \ldots$ (10 poin)
6. $(25 - 3) \times 5 = \ldots$ (10 poin)
7. $18 \times 4 = \ldots$ (10 poin)
8. $(27 - 5) \times (5 + 2) = \ldots$ (10 poin)
9. $(7 + 6) \times 6 + 10 = \ldots$ (10 poin)
10. $5 \times (20 - 8) \times 4 = \ldots$ (10 poin)

Figure 5. Baseline-1's Answer (A)



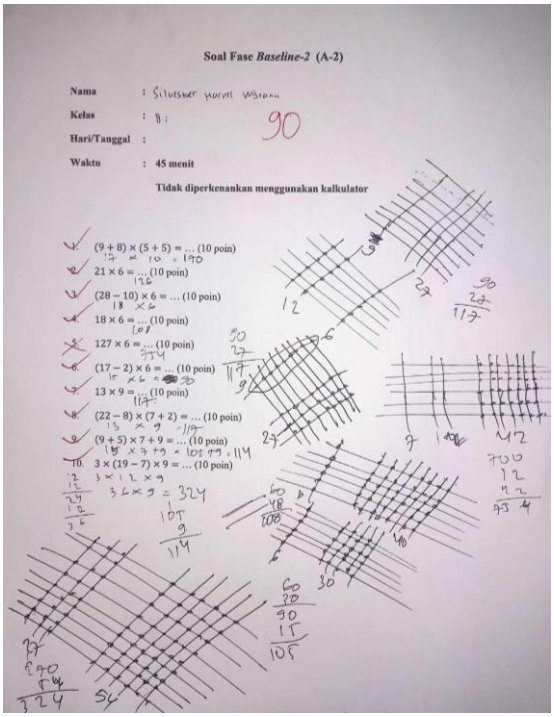
Soal Fase Intervensi (B)

Nama :
Kelas :
Hari/Tanggal :
Waktu : 45 menit

Tidak diperkenankan menggunakan kalkulator

1. (12 + 4) × (4 + 5) = ... (10 poin)
2. 17 × 5 = ... (10 poin)
3. (15 − 3) × 8 = ... (10 poin)
4. 14 × 7 = ... (10 poin)
5. 132 × 5 = ... (10 poin)
6. (28 − 3) × 5 = ... (10 poin)
7. 17 × 5 = ... (10 poin)
8. (21 − 5) × (4 + 8) = ... (10 poin)
9. (5 + 7) × 3 + 10 = ... (10 poin)
10. 5 × (15 − 5) × 4 = ... (10 poin)

Figure 6. Intervention's Answer (B)



Soal Fase *Baseline-2* (A-2)

Nama :
Kelas :
Hari/Tanggal :
Waktu : 45 menit

Tidak diperkenankan menggunakan kalkulator

1. (9 + 8) × (5 + 5) = ... (10 poin)
2. 21 × 6 = ... (10 poin)
3. (28 − 10) × 6 = ... (10 poin)
4. 18 × 6 = ... (10 poin)
5. 127 × 6 = ... (10 poin)
6. (17 − 2) × 6 = ... (10 poin)
7. 13 × 9 = ... (10 poin)
8. (22 − 8) × (7 + 2) = ... (10 poin)
9. (9 + 5) × 7 + 9 = ... (10 poin)
10. 3 × (19 − 7) × 9 = ... (10 poin)

Figure 7. Baseline-2's Answer (A)

The findings of this study can be interpreted through the lens of Bruner's theory of iconic representation, which emphasizes the role of visual imagery in cognitive development, particularly when learners face challenges with abstract reasoning (Bruner, 1966). The GARISMATIKA method aligns with this theoretical model by converting multiplication into a visual activity involving intersecting lines and counting points – an approach that serves as a concrete representation to enhance student comprehension. This is further supported by Ausubel's theory of meaningful learning, which stresses the

importance of connecting new information to relevant prior knowledge (Ausubel, 1968). GARISMATIKA operationalizes this concept by offering a structured and memorable strategy that frames multiplication as repeated addition, grounded in spatial logic. The method is also congruent with Mayer's cognitive theory of multimedia learning, which advocates for integrating verbal and visual modalities to optimize understanding (Mayer, 2009).

Beyond cognitive development, the intervention also yielded notable affective and behavioral benefits. Qualitative observations during the study revealed a marked shift in the student's disposition toward mathematics – characterized by heightened motivation, reduced anxiety, and greater persistence in completing tasks. This transformation aligns with research indicating that affective variables such as self-efficacy and math anxiety significantly influence students' performance in mathematics (Pajares & Graham, 1999; Ashcraft & Moore, 2009). These insights affirm that effective instructional strategies must address not only content delivery but also the emotional and motivational dimensions of learning – especially in students with learning difficulties (Dowker, 2005; Jordan & Levine, 2009).

This study contributes uniquely to the field of special and inclusive mathematics education. While previous investigations – such as those by Arisandi and Siagian – have established the effectiveness of GARISMATIKA at the elementary level and among students with various disabilities, the current study introduces several important innovations. First, it applies the GARISMATIKA method at the junior secondary school level, thereby addressing a significant gap in the literature, as most interventions for dyscalculia target younger learners (Fuchs, Fuchs, D., Compton, Powell, Seethaler, Capizzi, & Schatschneider, 2010). Second, the study focuses on three-digit multiplication problems, which involve higher-order cognitive demands than the simpler arithmetic operations typically explored in earlier GARISMATIKA research (Gersten et al., 2005). Third, it employs an A–B–A (reversal) research design, which offers a more rigorous assessment of the intervention's sustainability compared to the more common A–B designs (Gast & Ledford, 2014).

Collectively, these contributions underscore the academic significance and innovative nature of this study. GARISMATIKA emerges as a scalable, effective, and developmentally appropriate instructional strategy that can support learners struggling with more complex arithmetic operations in later stages of schooling. From a theoretical standpoint, the study reinforces the value of visual-spatial learning strategies for students with neurocognitive challenges, providing evidence that such approaches remain effective well beyond the early years of education (Mazzocco & Myers, 2003). From a practical perspective, the study offers educators – particularly those working in inclusive or resource-constrained classrooms – a low-cost, hands-on, and engaging tool for enhancing conceptual understanding of multiplication. The simplicity and adaptability of the method make it highly compatible with principles of differentiated instruction (Tomlinson, 2014; Friend & Bursuck, 2018), thus promoting equitable access to quality mathematics education for all learners.

Conclusion

This study concludes that the GARISMATIKA method exerts a significant and sustained impact on improving multiplication performance in students with dyscalculia, particularly in addressing the cognitive demands of three-digit multiplication. By transforming abstract numerical concepts into concrete visual representations, the method facilitates both cognitive understanding and affective engagement. It not only enhances accuracy and retention but also fosters positive changes in student motivation, confidence, and attitude toward mathematics. The application of GARISMATIKA at the junior secondary level broadens its pedagogical relevance and demonstrates its potential within inclusive education frameworks. These findings affirm the method's viability as a low-tech, cost-effective intervention suitable for diverse educational settings. Given the promising outcomes, future research is encouraged to replicate and expand this study with larger, more heterogeneous populations to further examine the method's generalizability and scalability. Furthermore, exploring digital or app-based adaptations of GARISMATIKA may open new pathways for implementation in blended and remote learning environments. Ultimately, GARISMATIKA represents a compelling instructional strategy that aligns with the goals of equitable, inclusive, and effective mathematics education, offering both theoretical significance and practical utility for educators and learners alike.

Acknowledgments

The researchers extend their sincere appreciation to the principal and teachers of SMP Negeri 9 Bogor for their support and cooperation in facilitating this research. Special thanks are also due to the participating student, whose engagement and willingness contributed meaningfully to the study's success.

Ethical Statement

This study was conducted in full compliance with ethical standards for research involving human participants. Prior to data collection, ethical approval was obtained from the relevant institutional review board overseeing educational research. Informed consent was secured from all stakeholders, including the student participant, their parents or legal guardians, and the school authorities at SMP Negeri 9 Bogor. The identity of the student was anonymized using a pseudonym to ensure confidentiality, and all data were collected, stored, and reported in a manner that protects participant privacy. The research posed minimal risk and involved no physical or psychological harm. Participation was voluntary, and the participant retained the right to withdraw at any stage without penalty. The intervention employed in this study – the GARISMATIKA method – was educational in nature and integrated with regular learning activities to minimize disruption. The study adhered to the ethical guidelines set forth by the Indonesian Ministry of Education and relevant international standards for educational research.

CRediT Author Statement

- **Author 1:** Conceptualization, Methodology, Investigation, Writing – Original draft preparation, Formal analysis.
- **Author 2:** Conceptualization, Writing – Reviewing and Editing, Formal analysis.

Conflict of Interest

The authors declare that there are no competing financial interests or personal relationships that could have influenced the work reported in this article.

Data Availability

The datasets generated and analyzed during the current study are available upon reasonable request.

References

Agbata, B. C., Obeng-Denteh, W., Kwabi, P. A., Abraham, S., Okpako, S. O., Arivi, S. S., ... & Adu, G. W. (2024). Everyday uses of mathematics and the roles of a mathematics teacher. *Science World Journal*, *19*(3), 819-827. https://scienceworldjournal.org/article/view/24035.

Akhter, N., & Akhter, N. (2018). Learning in Mathematics: Difficulties and Perceptions of Students. *Journal of Educational Research (1027–9776)*, *21*(1). https://jer.iub.edu.pk/journals/JER-Vol-21.No-1/11.pdf.

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment, 27*(3), 197–205.

Auliya, M. F. (2012). *Mastermatika Dahsyat*. Jakarta: Pustaka Widyatama.

Ausubel, D. P. (1968). *Educational psychology: A cognitive view*. Holt, Rinehart and Winston.

Azhari, B. (2017). Identifikasi gangguan belajar dyscalculia pada siswa madrasah ibtidaiyah. *Al-Khawarizmi: Jurnal Pendidikan dan Pembelajaran Matematika*, 1(1), 1–10. https://doi.org/10.22373/jppm.v1i1.1732.

Barr, J., & Griffiths, M. (2007). The nature of knowledge and lifelong learning. In *Philosophical perspectives on lifelong learning* (pp. 189–210). Dordrecht: Springer Netherlands. https://link.springer.com/chapter/10.1007/978-1-4020-6193-6_12.

Bruner, J. S. (1966). *Toward a theory of instruction*. Harvard University Press.

Butterworth, B. (2005). Developmental dyscalculia. In *Handbook of Mathematical Cognition* (pp. 455–467).

Cakiroglu, O. (2012). Single subject research: Applications to special education. *British Journal of Special Education*, 39(1), 21–29. https://doi.org/10.1111/j.1467-8578.2012.00530.x.

Collins, R. (2014). Skills for the 21st Century: teaching higher-order thinking. *Curriculum & Leadership Journal*, *12*(14), 1–8. https://valleyteams.com/wp-content/uploads/2015/10/curriculum-leadership-journal-skills-for-the-21st-century-teaching-higher-order-thinking.pdf.

Desoete, A., & Roeyers, H. (2005). Cognitive skills in mathematical problem solving in children with learning disabilities. *Learning and Instruction, 15*(5), 435–449. https://doi.org/10.1348/000709904x22287.

Dowker, A. (2005). *Individual differences in arithmetic: Implications for psychology, neuroscience, and education*. Psychology Press.

Evans, K., Schoon, I., & Weale, M. (2013). Can lifelong learning reshape life chances?. *British Journal of Educational Studies*, *61*(1), 25–47. https://doi.org/10.1080/00071005.2012.756163.

Friend, M., & Bursuck, W. D. (2018). *Including students with special needs: A practical guide for classroom teachers* (8th ed.). Pearson.

Fuchs, L. S., Fuchs, D., Compton, D. L., Powell, S. R., Seethaler, P. M., Capizzi, A. M., & Schatschneider, C. (2010). The cognitive correlates of third-grade skill in arithmetic, algorithmic computation, and arithmetic word problems. *Journal of Educational Psychology, 102*(3), 563–580. https://psycnet.apa.org/doi/10.1037/0022-0663.98.1.29.

Gast, D. L., & Ledford, J. R. (2014). *Single case research methodology: Applications in special education and behavioral sciences* (2nd ed.). Routledge.

Geary, D. C. (2011). Cognitive predictors of achievement growth in mathematics: A five-year longitudinal study. *Developmental Psychology, 47*(6), 1539–1552. https://doi.org/10.1037/a0025510.

Gersten, R., Jordan, N. C., & Flojo, J. R. (2005). Early identification and interventions for students with mathematics difficulties. *Journal of Learning Disabilities, 38*(4), 293–304. https://doi.org/10.1177/00222194050380040301.

Heyd-Metzuyanim, E., & Sfard, A. (2012). Identity struggles in the mathematics classroom: On learning mathematics as an interplay of mathematizing and identifying. *International Journal of Educational Research*, *51*, 128–145. https://doi.org/10.1016/j.ijer.2011.12.015.

Jordan, N. C., & Levine, S. C. (2009). Socioeconomic variation, number competence, and mathematics learning difficulties in young children. *Developmental Disabilities Research Reviews, 15*(1), 60–68. https://doi.org/10.1002/ddrr.46.

Kansal, P., & Sadawarti, H. (2022). Predicting employability of computer science graduates: The role of cognitive, non-cognitive, and emotional quotient abilities. *GMSARN International Journal*, *16*, 523-536. https://gmsarnjournal.com/home/wp-content/uploads/2024/05/vol19no1-13.pdf.

Mayer, R. E. (2009). *Multimedia learning* (2nd ed.). Cambridge University Press.

Mazzocco, M. M., & Myers, G. F. (2003). Complexities in identifying and defining mathematics learning disability in the primary school-age years. *Annals of Dyslexia, 53*(1), 218–253. https://doi.org/10.1007/s11881-003-0011-7.

Miller, S. P., & Mercer, C. D. (1993). Using data to learn about concrete–semiconcrete–abstract instruction for students with math disabilities. *Learning Disabilities Research & Practice, 8*(2), 89–96. https://psycnet.apa.org/record/1994-23423-001.

Misrom, N. B., Muhammad, A., Abdullah, A., Osman, S., Hamzah, M., & Fauzan, A. (2020). Enhancing students' higher-order thinking skills (HOTS) through an inductive reasoning strategy using geogebra. *International Journal of Emerging Technologies in Learning (iJET)*, *15*(3), 156–179. https://doi.org/10.3991/ijet.v15i03.9839.

Montague, M. (2008). Self-regulation strategies to improve mathematical problem solving for students with learning disabilities. *Learning Disability Quarterly, 31*(1), 37–44. https://www.jstor.org/stable/30035524.

Pajares, F., & Graham, L. (1999). Self-efficacy, motivation constructs, and mathematics performance of entering middle school students. *Contemporary Educational Psychology, 24*(2), 124–139. https://doi.org/10.1006/ceps.1998.0991.

Pertiwi, H., Sayidiman, S., & Patta, R. (2023). The Application of Cross Line Method to Improve the Students' Counting Ability on Multiplication Operations Class IVB Elementary School. *Excellent Education, Science and Engineering Advances Journal*, *2*(2), 1-10. https://ojs.nubinsmart.id/index.php/eeseaj/article/view/148/172.

Riwanto, M. A., Budiarti, W. N., Baharudin, Y. H., Dwiyanti, A. N., & Winandika, G. (2022, September). Development of Interactive Media of Multiplication Materials with Line Technique (Garismatika) for 3rd Grade Elementary School. In *Proceeding PGSD UST International Conference on Education* (Vol. 3, No. 1, pp. 48-51). https://doi.org/10.30738/icepgsd.v3i1.588.

Santos-Trigo, M. (2020). Problem-solving in mathematics education. *Encyclopedia of mathematics education*, 686–693.

Sfard, A. (1991). On the dual nature of mathematical conceptions: Reflections on processes and objects as different sides of the same coin. *Educational Studies in Mathematics, 22*(1), 1–36. https://link.springer.com/article/10.1007/BF00302715.

Shek, D. T., Chau, C., Zhou, K., Chu, C. K., Chu, K., & Li, A. (2023). Nurturing holistic development of university students: The role of non-cognitive skills. *International journal of child and adolescent health*, *16*(2), 122. https://research.polyu.edu.hk/en/publications/nurturing-holistic-development-of-university-students-the-role-of.

Sultanova, G., Shilibekova, A., Rakhymbayeva, Z., Rakhimbekova, A., & Shora, N. (2024, March). Exploring the influence of non-cognitive skills on academic achievement in STEM education: the case of Kazakhstan. In *Frontiers in Education* (Vol. 9, p. 1339625). Frontiers Media SA. https://doi.org/10.3389/feduc.2024.1339625.

Suzana, Y., & Maulida, I. (2019). Mengatasi dampak negatif diskalkulia dalam menyelesaikan masalah matematika. *Logaritma: Jurnal Ilmu-Ilmu Pendidikan dan Sains*, 7(1), 15–22. https://doi.org/10.24952/logaritma.v7i01.1661.

Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability*, *12*(23), 10113. https://doi.org/10.3390/su122310113.

Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners* (2nd ed.). ASCD.

Utami, Y. P., & Cahyono, D. A. D. (2020). Study at home: Analisis kesulitan belajar matematika pada proses pembelajaran daring. *Jurnal Ilmiah Matematika Realistik*, 1(1), 20–26. https://www.researchgate.net/publication/349648944_Study_at_Home_Analisis_Kesulitan_Belajar_Matematika_pada_Proses_Pembelajaran_Daring.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Widodo, S. A., Cahyani, E. R., & Istiqomah, I. (2020). Single-subject research: Learning algebra operations in introverted students. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, 10(2), 133–142. http://dx.doi.org/10.30998/formatif.v10i2.6300.

Wilson, A. J., Revkin, S. K., Cohen, D., Cohen, L., & Dehaene, S. (2006). An open trial assessment of "The Number Race", an adaptive computer game for remediation of dyscalculia. *Behavioral and Brain Functions, 2*, 20. https://behavioralandbrainfunctions.biomedcentral.com/articles/10.1186/1744-9081-2-20.

Yofelia, N., & Efendi, J. (2019). Meningkatkan hasil belajar operasi pengurangan deret kebawah anak diskalkulia menggunakan gelas bilangan. *Ranah Research: Journal of Multidisciplinary Research and Development*, 2(1), 35–42. https://jurnal.ranahresearch.com/index.php/R2J/article/view/191.