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THE TEACHERS' ATTITUDES TOWARD MNEMONIC STRATEGIES IN IMPROVING THE BASIC MULTIPLICATION FACTS RETRIEVAL AMONG INCLUSIVE PRIMARY SCHOOL STUDENTS

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ABSTRACT

The current quasi-experimental comparative study investigated the teachers' attitudes toward Mnemonic strategies (Visual Imagery and Story-linking) compared to Traditional Strategies (Rote Learning, Multiplication Quizzes, Daily Multiplication Habit, and Repeated Addition Strategy) in enhancing basic multiplication fact retrieval among Grade 3 students with and without disabilities in 20 inclusive primary schools. A sequential explanatory mixed-methods design was adopted, prioritizing quantitative analysis to establish causal relationships, followed by qualitative exploration for more profound insight. The Non-equivalent Control Group Design (NECGD) was utilized in the quantitative phase, comprising 20 teachers: 10 in the experimental group (Mnemonic strategies) and 10 in the control group (Traditional Strategies). In addition, the authors administered a pre-test and post-test survey, which included questionnaires and open-ended questions, to measure changes in teachers' attitudes before and after the intervention. Moreover, interviews were conducted with the teachers to gather more in-depth qualitative data. Additionally, a Paired-Samples T-test revealed a statistically significant increase in teachers' positive attitudes toward Mnemonic strategies following a one-day professional development program ($t(9) = 15.00$, $p < 0.001$), indicating that exposure to innovative teaching strategies positively influenced the teachers' attitudes. Although the control group (Traditional Strategies) also showed significant improvement in their attitudes ($t(9) = 9.80$, $p < 0.001$), the experimental group demonstrated a more substantial change, suggesting that Mnemonic strategies were more effective in fostering a positive shift in teacher attitudes. The qualitative findings have also supported the quantitative results, highlighting the increasing confidence of teachers in using Mnemonic strategies to assist students with diverse learning needs. These results contribute to the broader discourse on teacher cognition, instructional efficacy, and inclusive pedagogy, underscoring the necessity of sustained professional development programs in promoting adaptive instructional practices.

Keywords: Mnemonic strategies, teacher attitudes, instructional efficacy, cognitive load theory, dual-coding theory, professional development, inclusive education

INTRODUCTION

Mathematics has a fundamental role in our daily lives, from marketing to social activities (National Mathematics Advisory Panel, 2008), and it facilitates understanding and enables endless opportunities (Nanda & Rani, 2025). In addition, mathematics is considered vital for success in daily life and professional careers (Lund et al., 2012). In their daily lives, students consistently apply their calculation and problem-solving skills in various contexts, including buying and selling businesses, using a clock, measuring objects, and other relevant tasks (Wulandary, 2020). Moreover, students aspiring to careers in technology or science development must dedicate themselves to mastering mathematics, as those who struggle in the subject may face challenges in obtaining appropriate employment (Treacy et al., 2012). Accordingly, students who are not competent in mathematics tend not to be proficient in advanced-level subjects, such as physics, chemistry, and economics (Wulandary & Kawai, 2024). Consequently, students should be adept in the basic concepts and calculations at the primary level, including addition or subtraction, by the end of Grade 3 and multiplication or division by the end of Grade 4 (Chapin & Johnson, 2006) as multiplication should be developed in Grade 3 according to the Core Curriculum Content Standards (Orefice, 2013). However, foundational math skills cultivated in early childhood education are critical to a child's academic development and future success (Nanda & Rani, 2025).

Basic math skills, such as multiplication, form the foundation for developing more advanced concepts (Nanda & Rani, 2025). Multiplication is an essential arithmetic skill that should be learned thoroughly at the primary level, after addition and subtraction, because they provide a base for understanding multiplication (Siegler & Braithwaite, 2016). Many students struggle to develop these skills, some relying on tally marks and counting by ones throughout primary school despite the relatively small size of the numbers involved in such calculations (National Council of Teachers of Mathematics, 2020). According to Huang and Chao (1999), students who fail to learn basic multiplication facts may lack the skills to address complicated problems.

The development of foundational skills in mathematics, particularly basic multiplication fact retrieval, plays a pivotal role in students' academic success, especially in primary education (Lund et al., 2012). Mastering multiplication facts is widely regarded as a fundamental building block in the education of mathematical skills, laying the foundation for advanced problem-solving and mathematical reasoning (Siegler & Braithwaite, 2016). For Grade 3 students, multiple skills can be challenging, particularly for those with disabilities, especially students with dyscalculia (Landerl, 2014), who may face additional barriers in learning basic arithmetic. In inclusive classrooms, where students with and without disabilities are learning together, teachers are tasked with creating an environment that meets the diverse learning needs of all students. Teachers must implement effective instructional strategies that support all students, ensuring that students with disabilities receive the same fundamental skills instruction as their peers (Wulandary, 2020).

In many countries, primary school teachers focus on teaching basic arithmetic, including the sum and product of numbers from 0 to 10, as well as related concepts such as differences and ratios (Kling & Kline, 2025). Traditional Strategies, such as rote learning and repetitive drills, are teacher-centered, lecture-based, and rigid (Abbacan et al., 2025) and have long been used to teach multiplication facts. Abbacan et al. (2025) defined rote learning as a memorization technique in which information is repeated multiple times until it becomes imprinted in memory, which can be disadvantageous for students with learning difficulties who struggle to cope with this teaching method. Moreover, Davis (2008) suggested that repetitive drills facilitate rapid, repeated practice of basic multiplication facts, which involve numerous tasks for students to answer as many as possible within a set time, typically one to three minutes.

Although traditional strategies are effective for some students, they may not sufficiently engage students with varying learning needs or provide the support required for those struggling with cognitive or learning difficulties (O'Connor, 2014). Students with disabilities, particularly those with learning disabilities such as dyscalculia, may find Traditional Strategies ineffective, often leading to frustration, disengagement, and a lack of confidence in their abilities (Miller & Glover, 2018). Such challenges underline the need for instructional approaches that are both effective and inclusive, providing equal opportunities for all students to succeed in mathematics.

Mnemonic strategies have gained attention as an alternative or supplementary approach to traditional methods (Kumar & Anjum, 2023). Mnemonic strategies involve the usage of memory aids, such as Visual Imagery, Rhymes, or Story-linking, to facilitate the retention and retrieval of information (Mastropieri & Scruggs, 2010). The efficacy of these strategies is attributable to their capacity to establish significant associations or mental images that facilitate memory, thereby providing students with effective recall mechanisms for information. In the case of multiplication facts, Mnemonic strategies are fruitful for creating vivid mental images or stories around numbers, which may help students with disabilities better understand and remember mathematical facts (Miller, 2020). While research has shown that Mnemonic strategies are advantageous in supporting students with learning difficulties in areas such as reading and spelling (Bellezza, 1981), there is still limited research exploring their impact on mathematics instruction, particularly for students with diverse learning needs in inclusive classrooms.

Teachers' attitudes toward instructional strategies play a significant role in their decision to adopt and implement both Mnemonic and Traditional Strategies in the classroom (Oluwaseun et al., 2020). Research has identified a direct correlation between teacher attitudes and the efficacy of pedagogical methods (Kartal, 2020). Specifically, teachers demonstrate a heightened propensity to employ teaching methods they deem conducive to their students' learning outcomes (Kaufman, 2017). Positive attitudes toward new teaching methods, such as Mnemonic strategies, can encourage teachers to incorporate these strategies into their practice, whereas skepticism or a lack of understanding can hinder their adoption (Baker et al., 2002). These findings underscore the necessity for a dual investigation: first, the efficacy of Mnemonic strategies employed by students, and second, the role of teachers' attitudes in facilitating their integration into the classroom environment. If teachers perceive Mnemonic strategies as valuable and feasible, they are more likely to use them effectively with their students, ensuring that all students benefit from their potential advantages.

When considering the importance of diversity in an inclusive educational context, where the heterogeneity of students' needs is central, educators must feel confident and equipped to utilize various teaching strategies that cater to the diverse abilities of students (Loreman et al., 2005). Teachers' professional development programs have become pivotal factors in altering prevailing attitudes and enhancing pedagogical practices (Kennedy, 2016). Professional development can equip teachers with the knowledge and skills necessary to incorporate new strategies into their teaching, while also addressing concerns or uncertainties about unfamiliar methods (Darling-Hammond et al., 2017). One-day professional development programs focusing on specific strategies, such as Mnemonic techniques, demonstrate positive effects on teachers' confidence and attitudes toward implementing these strategies in their classrooms (Guskey, 2002).

The significance of this study lies in its contribution to the broader discourse on inclusive education and teacher professional development. This study investigates teachers' attitudes toward Mnemonic strategies and their effectiveness in improving multiplication fact retrieval for students with and without disabilities. The goal is to provide insights by integrating these strategies within inclusive teaching methodologies. Additionally, understanding how professional development programs influence teacher attitudes will inform future efforts to provide educators with the necessary tools and resources to implement evidence-based strategies effectively. This study is of considerable importance, as inclusive education remains a focal point of educational policy and practice worldwide. Teachers well-equipped with effective, inclusive teaching strategies can play a vital role in ensuring that all students, regardless of their abilities, can succeed in mathematics.

Research Aims and Objectives

This study aimed to investigate teachers' attitudes toward Mnemonic strategies (Visual Imagery and Story Linking) compared to Traditional Strategies (Rote Learning, Multiplication Quizzes, Daily Multiplication Habit, and Repeated Addition Strategy) in teaching basic multiplication facts to Grade 3 students with and without disabilities in inclusive primary schools. The study aimed to investigate whether exposure to Mnemonic strategies affected teachers' attitudes and confidence in adopting innovative instructional approaches. The specific objectives of this study were to:

1. To examine how teachers' attitudes toward Mnemonic versus Traditional Strategies for improving basic multiplication fact retrieval among Grade 3 students with and without disabilities in inclusive elementary schools differ.
2. To investigate how participation in a one-day professional development program influences teachers' attitudes toward Mnemonic strategies and Traditional Strategies.
3. To explore the qualitative insights that explain the changes in teachers' attitudes toward Mnemonic strategies and their confidence in using them to support students with diverse learning needs.

Research Questions

Based on the above study background, the authors examined two research questions. The research questions focused on how Mnemonic strategies influenced teachers' attitudes toward instructional practices in teaching basic multiplication facts to students with and without disabilities in inclusive primary schools. Three research questions are as follows:

1. How did teachers' attitudes toward Mnemonic versus Traditional Strategies for improving basic multiplication fact retrieval among Grade 3 students with and without disabilities in inclusive elementary schools differ?
2. How did participation in a one-day professional development program influence teachers' attitudes toward Mnemonic strategies and Traditional Strategies?
3. What qualitative insights explained the changes in teachers' attitudes toward Mnemonic strategies and their confidence in using them to support students with diverse learning needs?

Hypotheses

In the current study, the authors tested hypotheses to examine significant differences in teachers' attitudes toward instructional practices after exposure to Mnemonic strategies (experimental group) and Traditional Strategies (control group). The hypotheses for this quasi-experimental study are as follows:

1. H_0 (Null Hypothesis): There is no significant difference in the change of teachers' attitudes between those using Mnemonic strategies and those using Traditional Strategies.
2. H_1 (Alternative Hypothesis): There is a significant difference in the change in teachers' attitudes between those using Mnemonic strategies and those using Traditional Strategies.

The authors conducted a paired-sample T-test to determine the significance of attitude changes in the experimental and control groups. The p-value indicates whether H_0 is rejected or accepted, providing insight into the effectiveness of Mnemonic strategies in influencing teachers' attitudes toward instructional practices.

Rationale for the Study

Inclusive classrooms present a particular set of challenges to educators, as they must address diverse learning needs in a single setting. Teachers' instructional strategies play a crucial role in shaping students' learning experiences. While Mnemonic strategies are well-known for enhancing memory and retrieval processes, limited research has explored their impact on teachers’ attitudes and willingness to integrate them into their instructional practices. Understanding how teachers respond to innovative strategies is crucial for enhancing professional development programs and promoting effective, inclusive teaching practices. This study contributes to the broader discourse on teacher cognition, instructional efficacy, and inclusive pedagogy.

Scope of the Study

The authors conducted the study in 20 inclusive primary schools, involving 20 teachers who joined a professional development program. The study employed a sequential explanatory mixed-methods

design, incorporating quantitative analysis through pre-test and post-test surveys, as well as qualitative insights from teacher interviews. The focus was on investigating changes in attitude rather than measuring direct student performance outcomes.

Organization of the Report

This report is structured as follows:

Chapter 1 introduces the research problem, objectives, rationale, and hypotheses, providing a foundation for the study of the teachers' attitudes toward Mnemonic strategies in inclusive mathematics instruction.
Chapter 2 reviews the relevant literature on the subject, including Mnemonic strategies, teacher attitudes, cognitive theories, and inclusive mathematics instruction.
Chapter 3 outlines the research methodology, detailing the study design, participants, data collection procedures, and analysis techniques employed in both the quantitative and qualitative phases of the study.
Chapter 4 presents the quantitative research findings on teacher attitudes before and after the professional development program, supplemented by qualitative analysis.
Chapter 5 explores the implications of the findings for instructional praxis, pedagogical professional development, inclusive education policy, and future research directions.
Chapter 6 concludes the study by summarizing key findings, limitations, and recommendations for educators, policymakers, and researchers.

LITERATURE REVIEW

Students who recall multiplication facts swiftly and accurately have a strong foundation for future mathematical learning. However, many students, particularly those with learning difficulties, struggle with retrieval due to weaknesses in working memory, processing speed, and number sense (Fuchs et al., 2010; Geary et al., 2012). Students with mathematics difficulties often rely on inefficient counting strategies that hinder their progression to higher-order tasks (Baroody, 2006). Although timed drills and rote memorization are common, their effects are inconsistent and frequently limited for students with disabilities (Burns et al., 2015).

Mnemonic strategies, memory aids, and verbal cues, combined with Visual Imagery or Story-linking, offer a theoretically grounded alternative. Dual-coding theory (Paivio, 1986) posits that information encoded verbally and visually is more durable, and emerging evidence supports the use of mnemonics in mathematics (Miller, 2020; Wong & Butler, 2012). By reducing cognitive load, mnemonics can foster automaticity in fact retrieval; however, their application in inclusive mathematics classrooms remains underexplored.

Teachers' beliefs strongly shape the uptake of new methods. Unfamiliarity with Mnemonic strategies and doubts about their relevance to mathematics can hinder classroom adoption (Kaufman, 2017; Darling-Hammond et al., 2017). Well-designed professional development can address these concerns by enriching content knowledge and strengthening self-efficacy (Guskey, 2002; Desimone, 2009). However, only a small number of previous studies have investigated how professional development influences teachers' willingness to use Mnemonic strategies for diverse learners.

In conclusion, most studies focus on traditional drills to improve fluency. These studies rarely provide evidence on two critical topics: how Mnemonic strategies work for students with and without disabilities, and the role of professional development in shaping teachers' attitudes and practices. Accordingly, this study seeks to address these gaps by investigating (1) how teachers' attitudes differ toward Mnemonic strategies versus traditional strategies for improving basic multiplication facts retrieval among Grade 3 students with and without disabilities in inclusive primary schools; (2) the impact of professional development on teachers' attitudes of these instructional techniques; and (3) qualitative insights into how and why teachers' attitudes and confidence in using Mnemonic strategies evolve to support students with diverse learning needs. By addressing these gaps, this research aims to

contribute to the broader discourse on inclusive mathematics education and inform evidence-based instructional practices.

METHODOLOGY

Participants and Sampling

The study involved 20 Grade 3 teachers from 20 Islamic-inclusive primary schools, supervised by the Ministry of Religious Affairs in Purwakarta City, West Java, Indonesia. Participants were selected using purposive sampling, ensuring that the sample represented teachers with experience in inclusive education and those who have taught students with disabilities. Each participant was required to meet the following inclusion criteria: (1) At least three years of teaching experience in primary education, (2) Experience in teaching students with a variety of learning needs, (3) Active involvement in professional development programs related to inclusive education. Teachers who did not meet these criteria were excluded from the study.

Data Collection Procedures

The current study started in September 2019 after receiving official approval from the Ministry of Religious Affairs in Purwakarta City. The authors were granted access to 20 Islamic-inclusive primary schools for the purpose of this study. The authors visited each school to deliver formal permission letters for the study. After obtaining consent from the school principals, the researcher engaged with Grade 3 teachers to distribute a survey designed for them. The authors also asked the teachers to assist in distributing students' pre-tests to measure their initial retrieval and comprehension of basic multiplication facts, which are highly related to the implementation of this study.

After collecting the responses to the preliminary teachers' survey and the students' pre-tests, the authors employed the Non-Equivalent Control Group Design (NECGD). According to Creswell and Creswell (2018), NECGD is a quasi-experimental design that utilizes intact groups without random assignment, comparing intervention results by selecting pre-existing groups and administering pre- and post-test data. The description of NECGD is shown in Table 1.

Table 1: The Non-Equivalent Control Group Design for Teachers' Survey

Group	Pre-test	Treatment	Post-test
Experiment	O	X	O
Control	O	C	O

Note: *O = The teachers' survey. X = teaching the basic multiplication facts using Mnemonic strategies (Visual Imagery and Story-linking). C = teaching the basic multiplication facts without Mnemonic strategies/using Traditional Strategies.*

According to Table 1, the authors assigned teachers to either the experimental or control groups in this study. Both groups completed a preliminary survey before the intervention. During the intervention phase, the experimental group implemented Mnemonic strategies (Visual Imagery and Story-linking), while the control group received no training or support intervention. On the other hand, teachers in control groups applied traditional teaching strategies (Rote Learning, Multiplication Quizzes, Daily Multiplication Habits, and Repeated Addition Strategy). After the intervention, a final survey was distributed to both groups to assess changes in teachers' attitudes toward Mnemonic and Traditional Strategies.

While analyzing the preliminary study data, the authors found that the responses to the open-ended questions in the teacher surveys were incomplete and lacked depth. However, in the first round, the responses did not provide sufficiently detailed information. Consequently, the authors needed to conduct semi-structured interviews with the teachers using open-ended questions before the workshop to gain a more comprehensive insight. These interviews involved 10 teachers who later participated in a workshop.

An expert in mathematics who worked as a lecturer became a speaker at a one-day professional development program. This workshop focused on training teachers to use Mnemonic strategies for teaching basic multiplication facts, along with additional content on effectively teaching mathematics to primary school students, especially those who struggle with math. After completing the training, the ten teachers implemented the Mnemonic strategies in their classrooms with students from the experimental group. Following the one-day workshop, the authors planned to distribute the post-survey to teachers after administering the students' final test three months later to see differences between the experimental and control groups. However, the outbreak of the COVID-19 pandemic led to nationwide school closures, preventing them from collecting the final data from the experimental and control groups as scheduled.

As a result, only three teachers participated in the online interviews in 2020, following the closure of all schools. However, their responses were detailed and informative, enabling the authors to draw conclusions and formulate recommendations based on the overall findings. Additionally, the authors distributed the final survey and administered the students' post-tests in 2022, when the original Grade 3 students had progressed to Grade 5. Unfortunately, the prolonged delay in data collection meant that both groups received various other interventions during the two-year gap, likely impacting the outcomes of the teachers' final survey and students' post-tests.

However, the outbreak of the COVID-19 pandemic led to nationwide school closures, preventing the authors from collecting the final data from the experimental and control groups as initially scheduled. As a result, only three teachers participated in follow-up online interviews in 2020. Despite the limited number, their responses were detailed and informative, helping to formulate key findings. Later, in 2022, the authors resumed data collection, distributing the final teacher surveys and administering the students' post-tests after the original Grade 3 students had advanced to Grade 5. However, the two-year delay introduced potential confounding factors, as both groups had been exposed to various additional interventions in the interim, which may have influenced the outcomes. A summary of the timeline is provided in Table 2 to clarify the phases and disruptions in the study's implementation.

Table 2: Timeline of Data Collection and Analysis Phases

Phase	**Activities**	**Timeframe**	**Notes/Adjustments Related to Pandemic**
Phase 1: Initial Preparation	Approval from the Ministry of Religious Affairs, school access, and initial engagement with principals and teachers	Sept 2019	No delays
Phase 2: Pre-tests & Surveys	Distribution of Pre-surveys for teachers and students and the student pre-tests (baseline data collection)	Oct 2019	No delays
Phase 3: Workshop & Training	One-day workshop on Mnemonic strategies with 10 teachers	Jan 2020	Conducted as planned
Phase 4: Initial Implementation	Teachers implement strategies in classrooms.	Feb – Mar 2020	Interrupted by school closures
Phase 5: Follow-up Interviews	Online interviews with three teachers to gather qualitative insights	May 2020	Conducted remotely due to school closures
Phase 6: Data Collection Resumption	Distribution of Post-surveys for teachers and students, and the student post-tests, which Conducted after school reopening (final data collection)	Apr – June 2022	Delayed by two years, students had moved to Grade 5

continued

Phase 7: Final Analysis	Comparative analysis of quantitative and qualitative data	July – Sept 2022	Data interpretation considered the time gap impact

Data Analysis Procedures

The current experimental study employed a mixed-methods approach, specifically using a sequential explanatory design. A mixed-methods approach integrates quantitative and qualitative research methods within a single study (Creswell, 2014; Fraenkel, Wallen, & Hyun, 2012). According to Shorten and Smith (2017), this approach involves collecting and analyzing quantitative and qualitative data within the same investigation. In a sequential explanatory design, the collection and analysis of quantitative data precede the qualitative phase, with the latter intended to provide deeper insights or explanations for the quantitative findings. This design usually emphasizes the quantitative component (Shorten & Smith, 2017).

1. Research Instrumentation

In the current study, the teachers' survey consists of personal information, questionnaires, and open-ended questions. The questionnaire used in this study was adapted from the Third Teaching and Learning International Survey (TALIS, 2018) and consists of 45 items. The author modified the questionnaire to focus on multiplication instruction and relevant teaching strategies in primary school settings. The authors replaced the original Likert scale with a six-point Likert scale to encourage more nuanced responses. This adapted instrument covers various dimensions of teachers' experiences, perceptions, and practices. The authors organized the questionnaire into seven main sections, each containing 10 items (except for personal information and open-ended questions), with specific evaluation criteria described in Table 3 below.

Table 3: Questionnaire Sections and Evaluation Criteria in Teachers' Survey

No.	Section	Number of Items	Likert Scale (1-6)
1.	Participation in School Development Programs	10	1 = No impact 2 = Small effect 3 = Moderate effect 4 = Average effect 5 = Tremendous effect 6 = Significant impact and implemented
2.	Teachers' Attitudes Toward Teaching Multiplication	10	1 = Strongly Disagree 2 = Disagree 3 = Slightly disagree 4 = Somewhat agree 5 = Agree 6 = Strongly agree
3.	Perceived Impact of Previous Strategies on Students	10	Same as Section 2
4.	Teachers' Emotional Responses to Teaching Multiplication	10	Same as Section 2
5.	Frequency of Teacher–Student Discussions	6	1 = Never 2 = Very rarely 3 = Rarely 4 = Occasionally 5 = Frequently 6 = Always
6.	Instructional Time Allocation for Teaching Multiplication	3	1 = Unable to rate 2 = Less than 20% 3 = 20%–40% 4 = 40%–60%

continued

			5 = 60%–80% 6 = More than 80%
7.	Use of Previous Strategies in Teaching Basic Multiplication Facts	5	Same as Section 2

In addition to questionnaires, the authors developed and included an open-ended questionnaire in the teachers' survey. A total of six questions were asked, focusing on the types of strategies used, the reasons behind their choices, the frequency of classroom discussions related to multiplication, the perceived positive impacts and possible side effects on students, the integration of technological tools, and the challenges encountered during implementation as listed in Table 4.

Table 4: Open-ended Questions in Teachers' Survey

No.	Open-ended Questions
1.	What kind of strategies were used to teach the basic multiplication facts?
2.	Why did you choose those strategies?
3.	How often do you discuss issues about multiplication with your students in class?
4.	What were the positive impacts of the strategies on the students? Were there any side effects?
5.	Did you utilize technological programs in conjunction with these strategies?
6.	Were there any challenges during the strategy implementations?

2. Quantitative Data Analysis: Paired Sample t-Test

In this study, the authors analyzed questionnaires quantitatively and open-ended questions qualitatively to identify general patterns and trends related to their instructional practices and familiarity with strategies to improve students' retrieval of basic multiplication facts.

The authors employed the Paired Sample t-test (t-test: Paired Two Samples for Means) to analyze the quantitative data obtained from the pre-test and post-test questionnaires. This statistical test is appropriate for comparing the means of two related groups—in this case, the same group of teachers before and after the intervention. Gravetter and Wallnau (2017) stated that a paired sample t-test is a statistical technique used when two sets of scores are obtained from the same group of participants, which helps to determine if there is a statistically significant difference between the two time points. This method was applied to the experimental and control groups to assess the changes in teachers' attitudes and practices regarding Mnemonic strategies for teaching multiplication. The steps of quantitative data analysis are shown in Figure 1.

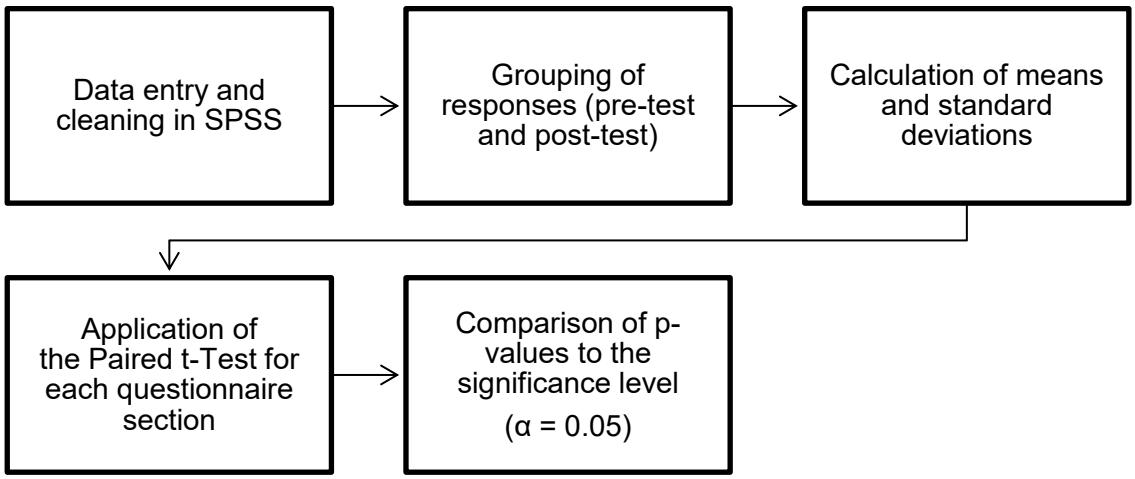

Figure 1: The steps of quantitative data analysis

3. Qualitative Data Analysis: Thematic Analysis with Data Triangulation

The qualitative data from the open-ended questions and interview responses were analyzed using data triangulation to ensure the validity and trustworthiness of the findings. Patton (1999) defined triangulation as the use of multiple sources of data or multiple methods to confirm the emerging findings, which enhances the credibility of the research.

The process involved coding and categorizing the responses, identifying patterns, and cross-verifying the findings between the open-ended responses and interview data. This approach enabled a deeper understanding of how and why teachers adopted specific strategies, their experiences with implementation, and the perceived impacts on student learning.

These interviews, along with teachers' written reflections and responses to open-ended questions, were analyzed qualitatively using thematic analysis to explore their perspectives and teaching experiences more thoroughly. These combinations provided qualitative data and analysis to enrich the findings and provide a contextual understanding of the intervention implementation. This integrated analysis enabled the authors to interpret the outcomes from multiple angles and generate comprehensive conclusions and recommendations. The steps of qualitative data analysis are shown in Figure 2.

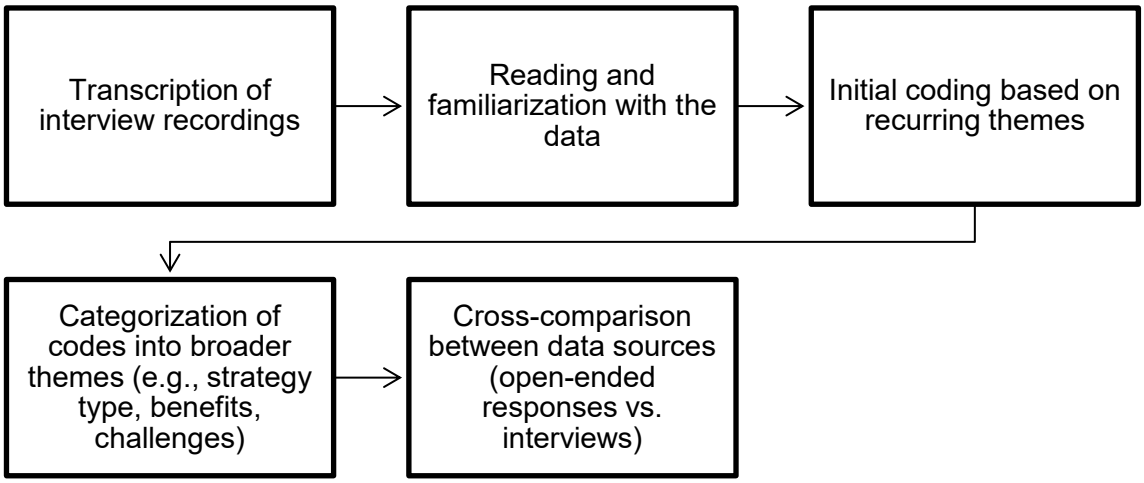

Figure 2: The steps of qualitative data analysis

RESULTS AND FINDINGS

Teachers' Questionnaire Results

Table 4 compares the teachers' attitudes toward Mnemonic strategies in the experimental group before and after participating in the professional development program. The mean score in the pre-test was 165.6, while the post-test mean increased to 193.9, indicating a notable improvement in attitudes. The statistical analysis using a paired two-sample t-test revealed a significant difference between the pre-test and post-test scores ($t = 15$, $df = 9$, $p < 0.001$, two-tailed), suggesting that the intervention had a substantial positive impact on the teachers' perspectives regarding the use of Mnemonic strategies in teaching.

Table 5: Mean Scores of Teachers' Attitudes Toward Mnemonic strategies in the Experimental Group

t-Test: Paired Two-Sample for Means	Post-test	Pre-test
Mean	193.9	165.6
Variance	20.3	48.9
Observations	10	10
Pearson Correlation	0.5	
Hypothesized Mean Difference	0	
df	9	
t	15	
p(T<=t) one-tail	5.6	
t Critical one-tail	1.8	
p(T<=t) two-tail	1.1	
t Critical two-tail	2.3	

In contrast, Table 6 shows the pre-test and post-test results for the control group, which did not receive the intervention. Mean scores were relatively stable, increasing slightly from 160.6 to 162.2. Although the paired t-test for this group also indicated a statistically significant difference ($t = 9.80$, $df = 9$, $p < 0.001$, two-tailed), the magnitude of change was minimal compared to the experimental group. Thus, external or natural factors (e.g., test repetition) rather than instructional interventions may contribute to the observed increase.

Table 6: Mean Scores of Teachers' Attitudes Toward Mnemonic Strategies in the Control Group

t-Test: Paired Two-Sample for Means	Post-test	Pre-test
Mean	162.2	160.6
Variance	49.7	51.2
Observations	10	10
Pearson Correlation	1	
Hypothesized Mean Difference	0	
df	9	
t	9.8	
p (T<=t) one-tail	2.1	
t Critical one-tail	1.8	
p (T<=t) two-tail	4.2	
t Critical two-tail	2.3	

Tables 5 and 6 present the paired samples' *t*-test results comparing the mean teacher attitudes toward Mnemonic strategies (experimental group) and Traditional Strategies (control group) before and after the interventions provided in the one-day teachers' workshop. Before the intervention, the experimental and control groups exhibited relatively similar attitudes toward both Mnemonic strategies and traditional strategies. However, a notable distinction emerged following the intervention.

The bar graphs in Figure 3 visualize the effectiveness of the intervention in the experimental group. In contrast to the marginal change in the control group, the substantial gap between the pre-test and post-test scores for this group supports the conclusion that the professional development workshop improved teachers' perceptions and acceptance of mnemonic teaching strategies.

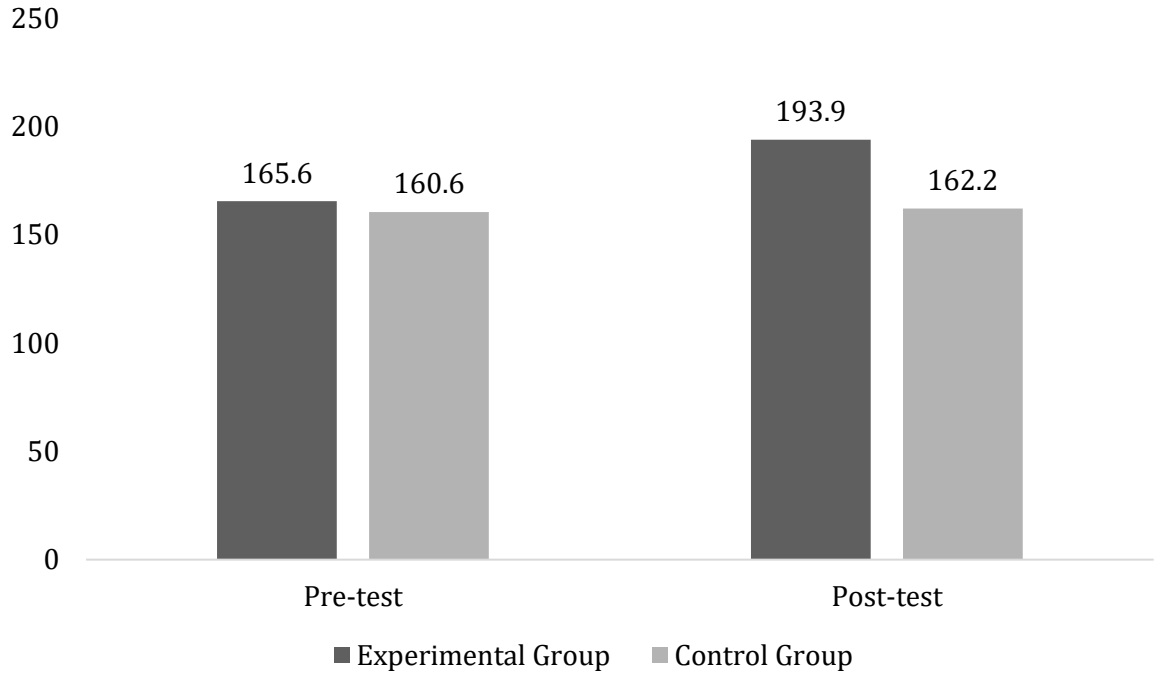

Figure 3: Comparison of Teachers' Attitudes Toward Mnemonic Strategies in Experimental and Control Groups

Overall, the results show that the professional development workshop significantly improved the experimental groups' attitudes toward mnemonic strategies for retrieving basic multiplication facts. The significant increase in the post-test mean score supports the effectiveness of professional development in providing teachers with practical and positive attitudes toward implementing Mnemonic techniques in their classrooms.

Open-Ended Questions and Semi-Structured Interview Findings

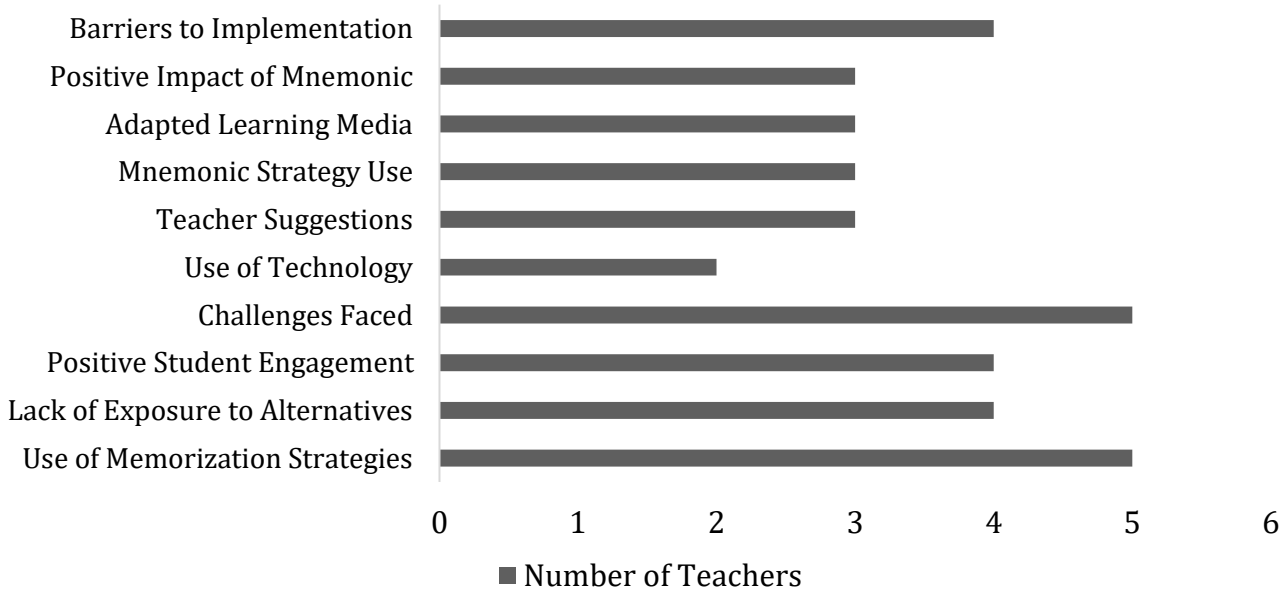

Figure 4: Themes Identified from Teachers' Open-ended Questions and Interviews

Figure 4 presents a qualitative analysis of teacher responses from the semi-structured interviews, highlighting key themes related to their experiences with Mnemonic strategies. The following is a representative sample:

1. Dominance of Memorization-Based Strategies

Most teachers reported relying on traditional memorization techniques, such as memorizing multiplication tables, taking quizzes, and participating in in-class challenges.

Example: One teacher explained, *"I usually ask students to memorize the multiplication table from 1 to 10 and give short quizzes every week. It's easier to manage, and students are already familiar with it."*

These strategies were chosen because they seemed simple, aligned with past successes, and familiar to both students and teachers.

Example: *"We've used this method for years, and it still works. The students seem to enjoy the little competitions we do in class,"* said another teacher.

2. Limited Exposure to Innovative Methods

Teachers admitted that they had little knowledge or training in alternative instructional approaches, which limited the variety of methods they used to teach.

Example: One teacher commented, *"No one introduced me to the strategies like using stories or visual tools to teach math. We only follow the book and what we've always done."*

3. Observed Positive Effects on Students

Teachers noted that rote memorization approaches boosted student motivation, engagement, and confidence, particularly when they were familiar with the methods.

Example: *"Some students were enthusiastic when we did small group competitions. They even reviewed the tables at home without being told to."*

Additionally, peer interaction increased as students supported one another.

Example: *"One student helped her classmate who was struggling. I could see their teamwork growing through this activity."*

4. Challenges and Unintended Consequences

Teachers observed that students with weaker memory or computational skills struggled to keep up, resulting in unequal outcomes.

Example: *"There were always a few kids who needed more time. I had to repeat the same lesson again and again just for them."*

High-achieving students would often disturb others after finishing early.

Example: *"Some students shouted out answers before others finished, which distracted the class."*

Other issues included a lack of focus, over-reliance on rote memorization, and minimal conceptual understanding.

5. Minimal Use of Technology

Due to infrastructure limitations, digital tools such as educational apps or software were almost non-existent in the classroom.

Example: *"Sometimes I use PowerPoint with a projector, but electricity can be unreliable. So I mostly stick to printed materials and the whiteboard."*

6. Teacher Suggestions for Improvement

Teachers suggested integrating more motivational activities and learning games to improve engagement in addressing these challenges.

Example: *"Maybe we can use games or group activities to make it more fun, especially for those who don't like memorizing."*

7. Implementation of Mnemonic strategies (Visual Imagery and Story-linking)

During the short period after the workshop, three teachers tried Mnemonic strategies for approximately one month before the COVID-19 lockdown.

a. **Teacher 1** exclusively used **Visual Imagery**, finding it practical for students with mathematical difficulties.
"I used pictures of bicycles to represent two because two wheels make it easier for students to grasp the idea of 2 times tables."
b. **Teacher 2** focused on **Story-linking**, highlighting its motivational effect.
"Students loved making stories. One created a funny tale about three cats eating three fish, which helped them remember 3 × 3 = 9."
c. **Teacher 3** used a combination of both methods but simplified **Story-linking** for students who struggled with reading.
"Some students couldn't follow the stories, so I dropped the words and just used pictures to keep it simple."

8. Adaptation of Learning Media

All three teachers adapted textbook-recommended media using available local resources.
Example: *"I didn't have the items from the book, so I used ice cream sticks and marbles. They're easy to find and do the job."*

They also expressed concern that textbooks often overlooked real classroom contexts.
Example: *"Sometimes the props in the book aren't realistic for our school. We have to be creative with what's around us."*

9. Positive Impact of Mnemonic Strategies

Visual Imagery helped students grasp multiplication concepts more intuitively and encouraged active participation.
Example: *"My students solved problems faster with pictures. They didn't need to count one by one anymore."*

Story-linking was especially effective in stimulating creativity and emotional engagement.
Example: *"The kids were laughing and making stories. Even the shy ones wanted to share their ideas in front of the class."*

10. Barriers and Limitations in Implementation

Despite the positive impact, teachers faced several obstacles: (1) Difficulty focusing among students with behavioral issues, (2) Pressure to complete multiple subjects under a tight curriculum, and (3) Psychological diversity and learning trauma.
Example: *"Some kids became anxious when they couldn't remember the multiplication facts. I had to slow down for them."*

After schools closed due to COVID-19, hands-on Mnemonic activities were discontinued as they did not fit remote learning formats.

Overall, Mnemonic strategies—particularly Visual Imagery—proved beneficial in making multiplication more accessible, engaging, and enjoyable. However, successful implementation depended on contextual adaptation, student characteristics, and available resources. Teachers emphasized the need for professional support, flexibility, and realistic curriculum expectations to ensure the sustainability of such innovative teaching practices in inclusive classrooms.

Summary of Key Findings

Several crucial findings regarding Mnemonic strategies for teaching multiplication in inclusive classrooms have emerged from the post-intervention survey and interview data. First and foremost, the authors found a significant improvement in attitudes toward Mnemonic strategies among teachers who participated in the professional development program. The mean score of the experimental group increased from 165.6 to 193.9, and the paired t-test result ($t = 15.00$, $p < 0.001$) indicated a statistically

significant shift. This finding suggests that the training had a substantial positive impact, successfully encouraging teachers to view Mnemonic strategies as beneficial tools, especially for supporting diverse learners.

In contrast, the control group—those who did not participate in the intervention—only showed an insignificant improvement in their attitude scores, from 160.6 to 162.2. Although this change was statistically significant ($t = 9.80$, $p < 0.001$), the practical difference was minimal, likely due to repeated testing or natural progression in awareness over time. This comparison further highlights the importance of structured professional development programs in transforming teacher attitudes and practices.

Before the intervention, most teachers relied on memorization-based strategies, such as multiplication drills, oral quizzes, and timed games. These methods were perceived as familiar and easy to manage, especially when teaching large, mixed-ability classes. While these approaches did encourage some level of enthusiasm, confidence, and cooperation among students, specifically through competitive activities, they also had limitations. Teachers implied that many students who struggled with memorization felt left behind, while faster learners often disrupted the class. Emphasizing speed and accuracy increased anxiety for some and provided little attention to the conceptual understanding of multiplying.

The interviews also highlighted that teachers had limited exposure to innovative teaching strategies. Most followed textbook-based instruction with little to no incorporation of visual or narrative techniques, such as visual imagery or Story-linking. Teachers admitted they had never been introduced to such methods and expressed interest in learning more. This lack of familiarity highlighted a gap in teacher training and curriculum resources, particularly in supporting students with special needs or those with memory difficulties.

Despite the limitations of traditional teaching approaches, teachers observed that students became more motivated and confident when learning multiplication through engaging methods, such as simple competitions or peer-supported learning. However, the long-term effectiveness of these Traditional Strategies remained questionable, as they often favored students with strong rote memory skills and neglected those who required alternative approaches.

Another notable finding was the limited use of technology in the classroom. Due to infrastructure challenges, such as unreliable electricity and insufficient access to digital devices, teachers rarely incorporated interactive tools into their lessons. Instead, they depended on printed worksheets, whiteboards, and other fundamental materials. This limitation restricted digital Mnemonics or gamified learning platforms that could have enhanced student engagement.

Interestingly, when introduced to Mnemonic strategies during the workshop, several teachers became enthusiastic about implementing them. In the follow-up interviews, three teachers shared how they applied Visual Imagery and Story-linking techniques in their classrooms. For example, one used visual metaphors, such as bicycles, to represent 2×2, while another created a narrative involving a cat eating three fish to explain 3×3. They found these strategies easy to modify according to students' reading abilities and backgrounds. Even students who usually struggled or were shy became more engaged during these lessons.

Teachers also adapted learning media using locally available materials, such as ice cream sticks and marbles, since textbook-recommended tools were often inaccessible or impractical. These adaptations revealed teachers' creativity and resourcefulness but pointed to a higher issue—the mismatch between centrally designed teaching resources and the conditions in rural or under-resourced classrooms.

In summary, using Mnemonic strategies has a positive effect on students' understanding and retention of multiplication facts, as well as emotional engagement and classroom participation. However, teachers identified several barriers to sustainable implementation. These included behavioral problems among students, curriculum time constraints, student psychological diversity, and the impact of school closures during the COVID-19 pandemic. These challenges suggest that while Mnemonic strategies are effective, their long-term success depends on ongoing professional support, inclusive curriculum planning, and greater attention to students' mental health and learning diversity.

DISCUSSIONS, CONCLUSIONS, AND RECOMMENDATIONS

Discussions Of Results

This study aimed to examine the effectiveness of Mnemonic strategies—specifically, Visual Imagery and Story-linking—in supporting the teaching of basic multiplication in inclusive classrooms. The findings from the post-intervention survey and interviews revealed several significant outcomes that offer important implications for practice, policy, and future research.

1. Hypothesis Support

The initial hypothesis posited that the professional development intervention would significantly improve teachers' attitudes and implementation of Mnemonic strategies in teaching multiplication. The data strongly support this hypothesis. The experimental group showed a substantial increase in attitude scores after the intervention, with the mean rising from 165.6 to 193.9 ($p < 0.001$), indicating a significant shift in perception. In contrast, the control group showed only a slight improvement (from a mean of 160.6 to 162.2), which was not due to external factors but rather generally attributed to the training. Moreover, the interviews revealed that teachers applied the Mnemonic strategies in their classrooms and reported increased student engagement, thus supporting the second part of the hypothesis regarding classroom application.

2. Meeting the Study Aims

The study successfully met its aims, which were to (1) investigate the existing strategies used by teachers in teaching multiplication, (2) introduce Mnemonic strategies through a professional development workshop, and (3) evaluate their impact on teacher attitudes and classroom practices. The results provide a vivid impression of teachers' reliance on traditional, memorization-heavy methods before the intervention and how exposure to alternative techniques, such as story linking and Visual Imagery, influenced their pedagogical approaches. The positive responses received from teachers and the changes observed in teaching practices confirm that the research objectives were met.

3. Comparison with Previous Research

The results are consistent with previous research showing that Mnemonic strategies improve retention, especially for students with learning disabilities (Scruggs & Mastropieri, 2000; Lubin & Polloway, 2016). Visual cues and narrative elements helped bridge abstract mathematical concepts with students' real-life experiences—an approach supported by Universal Design for Learning (UDL) principles. As implied by Maccini et al. (2007), the current study found that Mnemonic strategies increased academic students' performance, motivation, and confidence, especially in inclusive settings. However, this study makes a unique contribution by contextualizing these strategies in Indonesian inclusive primary schools, where infrastructural and curricular constraints often make it challenging to integrate innovative teaching practices.

4. Limitations and Challenges in Study Design

Despite its promising outcomes, the study faced several limitations. First, the short duration of the intervention limited the ability to observe long-term effects on student achievement. Before the COVID-19-related school closures, which disrupted the continuity of data collection and teacher support, the authors could only observe the implementation of the strategies for a short period. Second, relying on self-reported practices and interview data may introduce subjectivity or social desirability bias. Third, the small number of teachers interviewed after the intervention limits the generalizability of the qualitative findings. Moreover, the study did not incorporate direct classroom observations or pre-post assessments of student learning outcomes, which would have provided more objective measures of effectiveness.

Another challenge was that teachers could not fully explore digital Mnemonic tools or gamified learning due to a lack of digital tools and teaching resources. Additionally, behavioral problems and wide variations in students' psychological and cognitive skills added complexity to implementation in inclusive classrooms. These limitations suggest the need for more sustained professional

development, better alignment of textbooks with inclusive practices, and broader infrastructure support to ensure equitable access to quality mathematics education.

CONCLUSIONS

The current study aimed to investigate the efficacy of Mnemonic strategies—specifically, Visual Imagery and Story-linking—in teaching basic multiplication in inclusive primary classrooms. The study design effectively met its aims by providing a targeted professional development workshop and assessing its influence on teachers' attitudes and classroom practices. The results showed that the teachers embraced the training and implemented strategies to boost student engagement and support diverse learning needs.

The main implication is that Mnemonic strategies can serve as practical, low-cost tools to improve mathematical instruction in inclusive settings, specifically where resources are limited. The results also support the integration of Universal Design for Learning principles to make learning more accessible for all students.

However, the study faced limitations, including a short implementation period, a small sample size for post-intervention interviews, and the absence of direct measures of student learning outcomes. These factors limit the generalizability of the results and highlight the need for further investigation.

Future research should explore the long-term impact of Mnemonic strategies on student performance, incorporate classroom observations, and examine how digital tools can enhance Mnemonic-based instruction in inclusive education settings.

RECOMMENDATIONS

The authors proposed several key recommendations to enhance inclusive mathematics education, particularly in teaching basic multiplication. First, they recommend integrating Mnemonic strategies, such as Visual Imagery and Story-linking, into pre-service and in-service teacher training programs, as these approaches support diverse learners in inclusive classrooms. Moreover, the UDL principles are encouraged to help teachers flexibly adapt instructional methods and materials to accommodate a wide range of student needs.

Additionally, sustained implementation requires continuous support through mentoring and classroom-based supervision. Teachers should be guided in modifying textbooks using locally available materials, making lessons more relevant and accessible, particularly in low-resource contexts. Furthermore, policymakers are strongly encouraged to incorporate mnemonic-based instructional approaches into the national curriculum. This effort will foster more innovative and inclusive teaching practices.

Given the limitations encountered during this study, particularly the disruptions caused by COVID-19, future research should consider hybrid or asynchronous data collection methods (e.g., video-based classroom observations, online teacher journals, or virtual interviews) to ensure continuity even during emergencies. Establishing flexible and scalable research designs will enable more consistent data collection and better accommodate unexpected disruptions.

Further research should also evaluate the long-term impact of Mnemonic strategies on students' learning outcomes across diverse contexts and explore the use of simple pedagogical technologies that support different learning styles. Lastly, allowing teachers greater curriculum flexibility can facilitate differentiated instruction for students who require additional time or alternative approaches. These combined efforts aim to bridge the gap between inclusive education theory and practice, even under challenging circumstances.

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