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The Effectiveness of Abacus Strategies in Enhancing Arithmetic Performance: An Experimental Study

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Abstract

This study investigates the effectiveness of Abacus Strategies in enhancing arithmetic performance among Grade IV students using a quasi-experimental design. The sample comprised 80 homogeneous and equivalent students, divided into an experimental group (40 students) receiving Abacus-based instruction and a control group (40 students) taught using the conventional method. The study was conducted in two schools in Guntur, Andhra Pradesh. To facilitate the intervention, the researcher developed six structured modules covering addition and subtraction operations, ranging from single-digit to combined arithmetic applications. A pre-test and post-test were administered, each consisting of 25 arithmetic problems (15 addition, 10 subtraction), with a total score of 50 marks and a duration of 60 minutes. Data were analyzed using descriptive statistics (mean, standard deviation) and inferential statistics (paired t-test and independent t-test) to compare pre-test and post-test scores within and between groups. The findings revealed that while the conventional method led to a slight but statistically significant improvement, Abacus strategies resulted in a substantial enhancement in arithmetic performance. Moreover, students in the experimental group significantly outperformed those in the control group, demonstrating the greater effectiveness of Abacus-based instruction. These results suggest that Abacus training can serve as an effective pedagogical tool to improve numerical proficiency and mental computation skills in primary education. The study underscores the importance of integrating interactive and hands-on learning approaches to strengthen foundational numeracy, aligning with the National Education Policy (NEP) 2020.

Keywords: *Abacus strategies, arithmetic skills, primary education, quasi-experimental design, numeracy, conventional method, mathematics education, NEP 2020.*

1. Introduction

Primary education is crucial for a child's cognitive, social, and emotional development, laying the groundwork for academic success and lifelong learning. It nurtures essential skills like literacy, critical thinking, and problem-solving. Mathematics, a core subject at this level, plays a key role in developing logical reasoning, numerical proficiency, and analytical thinking. A strong math foundation supports cognitive growth and prepares students for advanced learning. Integrating interactive strategies like Abacus-based learning can make mathematics more engaging and effective, enhancing students' understanding, confidence, and overall academic performance.

2. Conceptual Background

Mathematical proficiency is a fundamental skill that plays a crucial role in a student's academic and cognitive development. Among various strategies for improving arithmetic skills, the abacus has been widely recognized as an effective tool for fostering numerical fluency, mental calculation, and problem-solving abilities. The abacus, an ancient calculating device, facilitates visual and kinesthetic learning, allowing students to develop a strong number sense and perform rapid calculations with accuracy. Research indicates that abacus-based training enhances working memory, concentration, and logical reasoning, making it an essential pedagogical tool for primary education. Despite advancements in digital learning tools, the abacus continues to be a valuable resource in strengthening foundational arithmetic skills, particularly in early education settings.

Arithmetical Skills for Primary School Students

Arithmetical skills are fundamental to primary education, supporting cognitive development and future success in mathematics. These skills—such as basic operations, number sense, and problem-solving—enable students to handle everyday tasks and build confidence in math. Research (Siegler & Lortie-Forgues, 2015; Baroody, 2006) shows that early arithmetic fluency predicts later achievement in advanced math. Effective instruction combines conceptual understanding with procedural fluency and benefits from tools like the abacus, game-based learning, and technology integration. Educators play a key role by using diverse strategies to ensure deep comprehension. Strengthening arithmetic skills early creates a solid base for lifelong mathematical competence.

Arithmetical Skills for Primary School Students

Arithmetical skills are vital in primary education, supporting young learners' cognitive and academic growth. These include basic operations, number sense, and problem-solving, which form the basis for confidence and success in mathematics. Research (Siegler & Lortie-Forgues, 2015; Baroody, 2006) highlights that early arithmetic fluency predicts achievement in advanced math areas like algebra. Effective instruction blends conceptual understanding with procedural fluency, using tools such as the abacus, games, and technology to enhance visualization and engagement (Wang et al., 2015; Sarama & Clements, 2009). Strengthening these skills early ensures a strong foundation for lifelong mathematical learning.

Abacus Strategies for Primary School Students

The abacus is a powerful tool for enhancing arithmetic skills in primary students by improving mental calculation, concentration, and numerical fluency. Abacus-based learning promotes a deeper understanding of mathematical operations through visualization and bead manipulation. Research (Stigler, 1984; Wang et al., 2015) shows that it enhances working memory, cognitive flexibility, and problem-solving speed. Techniques like the mental abacus method engage both brain hemispheres, boosting spatial reasoning and memory (Chen et al., 2006; Frank & Barner, 2012). Beyond math, abacus training supports overall cognitive development (Hatano et al., 1977), making it an effective strategy for foundational numeracy in primary education.

Difficulties in Arithmetic Skills Among Primary School Students in India

Many primary school students in India struggle with basic arithmetic due to rote-based teaching, poor conceptual understanding, and limited access to quality education. ASER (2022) reports that over half of Grade 5 students in rural areas cannot solve simple division problems, highlighting a major proficiency gap. Contributing factors include ineffective pedagogy, socio-economic challenges, language barriers, and overcrowded classrooms (Singh, 2017; Banerjee & Duflo, 2011; Mohanty, 2019). Traditional methods fail to address diverse learning needs, underscoring the need for activity-based, visual, and technology-enhanced strategies—such as abacus training—to improve engagement, understanding, and arithmetic confidence in young learners.

NEP 2020 and Arithmetic Skills Among Primary School Students in India

NEP 2020 prioritizes foundational numeracy and aims for all Grade 3 students to achieve basic literacy and arithmetic skills by 2025 through the National Mission on Foundational Literacy and Numeracy. In response to widespread arithmetic gaps reported by ASER, the policy promotes conceptual, activity-based learning over rote methods. It encourages tools like abacus, number games, and digital platforms to make math engaging and practical. NEP 2020 also emphasizes teacher training, use of regional languages, and technology integration to ensure inclusive, effective arithmetic instruction, laying a strong foundation for students' future academic success.

3. Need and Significance of the Study

The ability to perform arithmetic operations efficiently is a fundamental skill that lays the foundation for higher mathematical learning and real-world problem-solving. However, research and educational surveys, such as the Annual Status of Education Report (ASER, 2022), indicate that a significant percentage of primary school students in India struggle with basic arithmetic skills, including addition, subtraction, multiplication, and division. This learning gap is often attributed to rote memorization, inadequate teaching methodologies, and a lack of conceptual understanding. As mathematical competency is essential for cognitive development, academic success, and career readiness, it is crucial to explore effective pedagogical strategies that enhance arithmetic learning at the primary level. One such strategy is the abacus method, which has been widely recognized for its ability to improve numerical fluency, mental calculation, and problem-solving abilities.

This study is significant as it examines the effectiveness of abacus strategies in strengthening arithmetic skills among primary school students. Unlike traditional methods, abacus-based learning promotes visualization, active engagement, and cognitive flexibility, making arithmetic concepts more accessible and enjoyable for young learners. Additionally, the study aligns with the objectives of NEP 2020, which emphasizes foundational numeracy and aims to ensure that all children acquire basic arithmetic skills by Grade 3. The findings of this research will contribute to the growing body of knowledge on innovative teaching techniques and provide valuable insights for educators, policymakers, and curriculum developers. By integrating abacus strategies into early mathematics education, this study has the potential to bridge learning gaps, enhance student engagement, and improve overall mathematical proficiency, ultimately leading to better academic outcomes and lifelong numeracy skills.

This study aims to evaluate the effectiveness of abacus strategies in enhancing arithmetic skills among primary school students. Using an experimental design, the research examines the impact of abacus training on students' speed, accuracy, and conceptual understanding of arithmetic operations such as addition, subtraction, multiplication, and division. By comparing the performance of students who receive abacus instruction with those following conventional methods, the study seeks to determine whether abacus training offers significant advantages in mathematical skill development. The findings will contribute to the growing body of knowledge on innovative pedagogical approaches and provide insights into the role of hands-on learning techniques in mathematics education.

4. Literature Review

Abacus-based learning is widely recognized as an effective method to improve arithmetic skills in primary school students. Research shows that students trained in abacus techniques demonstrate greater accuracy, speed, and mental calculation abilities compared to those taught by conventional methods (Stigler, 1984; Wang et al., 2015). The abacus enhances not only numerical computation but also cognitive functions such as memory, concentration, spatial reasoning, and working memory through mental visualization, known as the "mental abacus" technique (Hatano et al., 1977; Chen et al., 2006). Neurological studies confirm that abacus training activates different brain regions linked to logical reasoning and problem-solving (Hanakawa et al., 2003). Beyond arithmetic, abacus skills correlate with better academic performance in other logical disciplines like science and engineering (Frank & Barner, 2012). It also increases student engagement and reduces math anxiety by providing a hands-on, visual learning experience (Sarama & Clements, 2009). Longitudinal research indicates sustained math achievement benefits for abacus-trained students (Takahashi, 2002). Additionally, abacus strategies serve as effective interventions for learners with difficulties such as dyscalculia

by offering kinesthetic and visual approaches to understanding numbers (Butterworth, 2005). The National Education Policy (NEP) 2020 supports integrating abacus training into foundational numeracy efforts, particularly to address learning gaps in underprivileged areas where rote learning predominates (Ministry of Education, 2020; ASER, 2022).

5. Objective:

1. To find the comparative effect of conventional method on arithmetic skills in the control group Pre and Post tests score of Primary school students.
2. To find the comparative effect of Abacus Strategies on arithmetic skills in the control group Pre and Post tests score of Primary school students.
3. To find the comparative effect of conventional method and Abacus Strategies on arithmetic skills in the control and experimental groups post test scores of Primary school students.

6. Hypotheses for the Study

1. **H_{01}:** There is no significant difference between the pre-test and post-test scores of primary school students in the control group taught using the conventional method.
2. **H_{02}:** There is no significant difference between the pre-test and post-test scores of primary school students in the experimental group taught using Abacus strategies.
3. **H_{03}:** There is no significant difference in the post-test scores between the control group (taught using the conventional method) and the experimental group (taught using Abacus strategies) in arithmetic skills.

7. Experimental Design

This study employed a quasi-experimental design to assess the effectiveness of Abacus Strategies in enhancing arithmetic skills among Grade IV students. The sample consisted of 80 homogeneous and equivalent students, divided into two groups: an experimental group (40 students) and a control group (40 students). The study was conducted in two schools located in Guntur, Andhra Pradesh.

Experimental Module (Treatment X_1)

To facilitate the intervention, the investigator developed **six structured modules** focusing on fundamental arithmetic operations:

- **Module I:** Addition – Single & Double Digits
- **Module II:** Subtraction – Single & Double Digits
- **Module III:** Application of Addition & Subtraction – Single & Double Digits
- **Module IV:** Combination in Addition
- **Module V:** Combination in Subtraction
- **Module VI:** Integrated Addition & Subtraction

Pre-Test and Post-Test

The pre-test was administered before the intervention to assess students' baseline arithmetic skills. It consisted of 25 problems, including 15 on addition and 10 on subtraction, with each problem carrying 2 marks, leading to a total score of 50 marks. The test duration was 60 minutes, ensuring students had adequate time to complete the assessment. After the intervention, a post-test was conducted, structured similarly to the pre-test. It comprised 25 problems on both addition and subtraction, each carrying 2 marks, maintaining the total score of 50 marks. The test duration remained 60 minutes to ensure uniformity in assessment conditions.

Reliability and Validity

The intrinsic validity of the test was determined through its reliability coefficient, where validity is represented as the square root of the reliability coefficient. The reliability values for the pre-test (0.889) and post-test (0.916) were found to be high, indicating that both tests were reliable and valid for measuring arithmetic skills accurately.

8. Data Analysis:

The collected data were analysed using descriptive statistics (mean, standard deviation) and inferential statistics (paired t-test and independent t-test) to assess the effectiveness of Abacus Strategies in enhancing arithmetic skills. The pre-test and post-test scores of both the experimental and control groups were compared to determine significant differences in students' arithmetic performance.

Objective-1

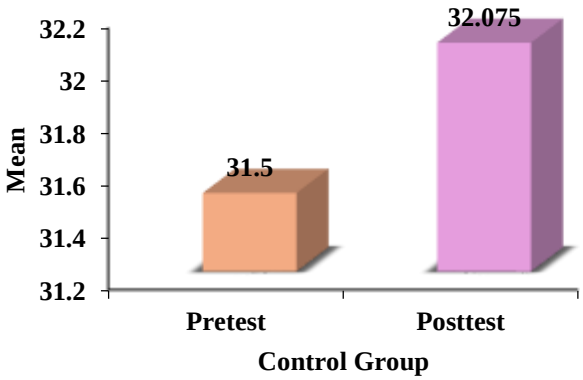
To find the comparative effect of conventional method on arithmetic skills in the control group Pre and Post tests score of Primary school students.

Hypothesis-1

H_{01}: There is no significant difference between the pre-test and post-test scores of primary school students in the control group taught using the conventional method.

Table 1. Effect of conventional method on arithmetic skills in pre and post-test of control group C.

N	Pre-test		Post-test		df	t-value	Result
40	Mean	S.D	Mean	S.D	39	2.890	Significant at 0.05 level
	31.50	8.72	32.075	9.373			



Graph 1. Mean difference of conventional method on arithmetic skills in pre and post-test of control group C

Interpretation

A paired-samples t-test was conducted to compare the arithmetic skills of primary school students in the control group before and after receiving instruction through the conventional method. The results indicated a statistically significant improvement in the post-test scores ($M = 32.08$, $SD = 9.37$) compared to the pre-test scores ($M = 31.50$, $SD = 8.72$), $t(39) = 2.89$, $p < 0.05$. This suggests that the conventional method led to a slight but meaningful enhancement in arithmetic skills among students in the control group. However, the magnitude of improvement appears limited, indicating the need for alternative or supplementary instructional approaches to strengthen arithmetic learning outcomes.

Finding

The conventional teaching method resulted in a slight but statistically significant improvement in arithmetic skills among primary school students in the control group.

Discussion

The study reveals a statistically significant yet modest improvement in arithmetic skills among primary school students taught through conventional methods. While traditional instruction aids procedural fluency, it lacks in promoting deep conceptual understanding and long-term retention. This is consistent with prior research (Singh, 2017; Baroody, 2006; ASER, 2022) indicating that rote-based learning limits arithmetic development. The findings highlight the need for integrating interactive and visual learning approaches, such as Abacus-based instruction and digital tools, which enhance mental computation and conceptual clarity (Frank & Barner, 2012; Nunes et al., 2007). The study recommends pedagogical reforms and further comparative research to evaluate the effectiveness of innovative versus traditional teaching methods in mathematics.

Objective-2

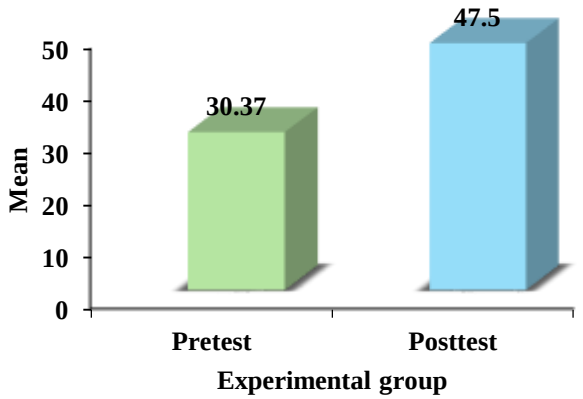
To find the comparative effect of Abacus Strategies on arithmetic skills in the control group Pre and Post tests score of Primary school students.

Hypothesis-2

H_{02}: There is no significant difference between the pre-test and post-test scores of primary school students in the experimental group taught using Abacus strategies.

Table 2. Effect of Abacus strategies on arithmetic skills in pre and post-test of Experimental group E.

N	Pre-test		Post-test		df	t-value	Result
40	Mean	S.D	Mean	S.D	39	10.872	Significant at 0.05 level
	30.37	10.36	47.50	1.63			



Graph 2. Mean difference of Abacus strategies on arithmetic skills in pre and post-test of Experimental group

Interpretation

A paired-samples t-test was conducted to compare the arithmetic skills of primary school students in the experimental group before and after receiving instruction using Abacus strategies. The results revealed a statistically significant improvement in the post-test scores (M = 47.50, SD = 1.63) compared to the pre-test scores (M = 30.37, SD = 10.36), $t(39) = 10.872$, $p < 0.05$. This substantial increase suggests that Abacus strategies were highly effective in enhancing arithmetic skills, leading to a marked improvement in students' numerical proficiency and computational accuracy.

Finding

Abacus strategies led to a statistically significant and substantial improvement in arithmetic skills among primary school students in the experimental group.

Discussion

The study demonstrates that Abacus strategies significantly enhance arithmetic skills among primary school students, as evidenced by marked post-test improvements in the experimental group. The findings support prior research indicating that visual and kinesthetic methods like the Abacus improve mental computation, cognitive flexibility, and numerical reasoning (Hatano et al., 1977; Frank & Barner, 2012; Chen et al., 2006). Aligning with NEP 2020's emphasis on experiential learning, Abacus training emerges as an effective intervention to address foundational numeracy gaps (ASER, 2022). The results advocate for integrating Abacus-based methods into primary curricula and encourage future studies on their long-term impact on advanced math skills and math-related challenges.

Objective-3

To find the comparative effect of conventional method and Abacus Strategies on arithmetic skills in the control and experimental groups post test scores of Primary school students.

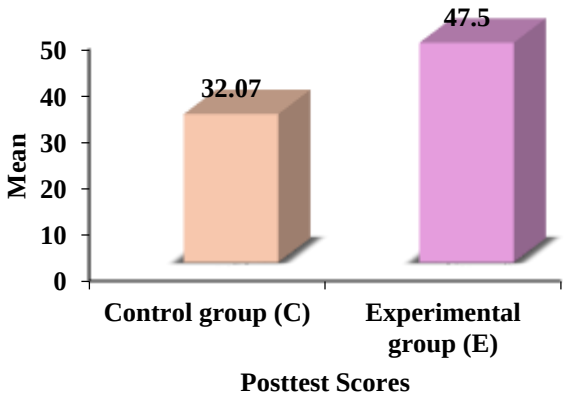
Hypothesis-3

H_{03}: There is no significant difference in the post-test scores between the control group (taught using the conventional method) and the experimental group (taught using Abacus strategies) in arithmetic skills.

Table 3. Comparative effect in Arithmetic Skills of two Groups C & E in Post-tests.

Note: * Significant at 0.05 level.

Group	Sample	Mean	SD	S. Ed	't' value	p value
Control group (C)	40	32.07	9.37	1.5044	10.253*	0.00
Experimental group (E)	40	47.50	1.63			



Graph 3. Mean difference in Arithmetic Skills of two Groups C & E in Post-tests

Interpretation

An independent-samples t-test was conducted to compare the post-test scores of primary school students in the control group (taught using the conventional method) and the experimental group (taught using Abacus strategies). The results revealed a statistically significant difference between the two groups, $t(78) = 10.253$, $p < 0.05$. The experimental group (M = 47.50, SD = 1.63) achieved significantly higher scores than the control group (M = 32.07, SD = 9.37), indicating that students who received Abacus-based instruction demonstrated greater improvement in arithmetic skills compared to those taught through the conventional method. This suggests that Abacus strategies are more effective in enhancing numerical proficiency, mental computation, and problem-solving abilities among primary school students.

Finding

Abacus strategies were significantly more effective than the conventional method in enhancing arithmetic skills among primary school students.

Discussion

The study reveals that primary school students taught using Abacus strategies significantly outperformed those taught through conventional methods in arithmetic skills, with a statistically significant difference in post-test scores ($p < 0.05$). The findings align with prior research (Hatano et al., 1977; Frank & Barner, 2012; Wang et al., 2015), highlighting the cognitive benefits of Abacus training—such as enhanced working memory, mental computation, and numerical accuracy. Consistent with NEP 2020 goals and ASER (2022) findings, the study supports integrating Abacus-based, experiential learning into early education to improve numeracy, reduce math anxiety, and close foundational learning gaps.

9. Educational Implications

1. **Curriculum Integration** – Abacus strategies should be incorporated into primary school mathematics curricula to enhance foundational numeracy skills.
2. **Pedagogical Shift** – Teachers should adopt interactive, hands-on learning approaches rather than relying solely on rote memorization methods.
3. **Cognitive Development** – Abacus training can improve working memory, concentration, and mental computation, benefiting overall academic performance.
4. **Teacher Training** – Educators should receive specialized training on Abacus-based instructional techniques to effectively implement them in classrooms.
5. **Bridging Learning Gaps** – Abacus strategies can serve as an intervention for students struggling with arithmetic, reducing math anxiety and improving confidence.
6. **Assessment Reforms** – Schools should adopt competency-based assessments that measure conceptual understanding rather than procedural recall.
7. **Technology Integration** – Digital Abacus applications and AI-driven learning tools can be used to enhance engagement and accessibility in mathematics education.
8. **Policy Implementation** – Educational policymakers should support the adoption of Abacus training programs in alignment with NEP 2020's focus on foundational numeracy.
9. **Parental Involvement** – Awareness programs can encourage parents to support Abacus learning at home to reinforce school-based instruction.
10. **Long-Term Impact** – Future studies should explore the sustained benefits of Abacus training on higher-order mathematical skills and overall cognitive growth.

10. Conclusion

This study examined the effectiveness of Abacus Strategies in enhancing arithmetic skills among Grade IV students through a quasi-experimental design. The findings revealed that while the conventional method resulted in a slight but statistically significant improvement, the Abacus-based intervention led to a substantial and highly significant enhancement in arithmetic performance. The experimental group consistently outperformed the control group in post-test scores, indicating that Abacus strategies are more effective than traditional teaching methods in strengthening numerical proficiency, mental computation, and problem-solving skills.

The results underscore the importance of adopting interactive, hands-on learning approaches in primary mathematics education. Abacus training provides a visual and kinesthetic learning experience, helping students develop conceptual understanding rather than relying solely on rote memorization. These findings align with the objectives of NEP 2020, which emphasizes experiential learning and foundational numeracy to address learning gaps in mathematics.

Given the significant impact of Abacus strategies, this study suggests the integration of Abacus training into primary school curricula to improve arithmetic skills and overall mathematical competency. Further research is recommended to explore the long-term effects of Abacus learning on higher-order mathematical skills and its applicability across diverse student populations. By incorporating innovative teaching methods, educators can create a more engaging and effective learning environment that fosters confidence and proficiency in mathematics among young learners.

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