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# A Structured Base Deviation Grid Method For Mental Multiplication And Its Pedagogical Implications

*Enhancing Number Sense and Computational Fluency*

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***Abstract:*** Mental computation is an essential element of mathematical understanding at the secondary school level, as it supports accuracy, efficiency, and numerical reasoning. However, classroom practice often emphasizes fixed procedural algorithms, which may limit students' conceptual flexibility and number sense. The present study introduces an innovative multiplication strategy, termed the Base Deviation Grid (BDG) Method, designed to provide a structured and systematic approach to base-oriented multiplication. To investigate its instructional effectiveness, a quasi-experimental pre-test–post-test control group design was employed with Grade IX students. Comparative analysis of achievement and speed measures revealed that students exposed to the BDG Method outperformed their peers taught through conventional multiplication techniques. The results indicate that structured mental-mathematics frameworks such as the BDG Method can significantly enhance students' computational performance and conceptual understanding in secondary mathematics classrooms.

***Index Terms*** **-** Mental Computation, Multiplication Techniques, Base Deviation Grid Method; Mathematics Pedagogy, Secondary Mathematics Education

## I. Introduction

The Base Deviation Grid (BDG) Method is an original technique developed by the researcher and is not directly adapted from existing Vedic mathematics or traditional base-multiplication approaches. It is designed as an independent instructional strategy grounded in structured numerical reasoning.

Multiplication serves as a fundamental operation underpinning advanced mathematical domains such as algebra, calculus, and data analysis. At the secondary school level, learners are expected to demonstrate not only computational accuracy but also flexibility, estimation ability, and a well-developed sense of number. Conventional multiplication algorithms, while effective for obtaining correct results, often emphasize procedural execution over conceptual understanding.

In recent years, educators and researchers have shown increasing interest in alternative computation strategies, including mental-math techniques and methods inspired by Vedic mathematics. Despite their potential benefits, many such approaches remain limited in scope, apply only to specific numerical cases, or lack a coherent structure for systematic classroom use. Addressing these limitations, the present study introduces the Base Deviation Grid (BDG) Method as a structured and generalized framework for multiplication that can be effectively applied across various numerical bases.

## II. Need and Significance of the Study

Secondary school students frequently exhibit errors in multiplication due to weak conceptual foundations and cognitive overload during multi-step calculations. Introducing a structured mental-math method can reduce computational burden and improve learner confidence.

The BDG Method is significant because it: - Provides a unified algebraic structure for base-based multiplication - Encourages number sense and estimation skills - Is easily adaptable for classroom teaching - Aligns with constructivist approaches to learning mathematics

This study is particularly relevant for mathematics educators seeking innovative yet systematic instructional strategies.

## III. Objectives of the Study

The objectives of the present study were: 1. To develop a structured Base Deviation Grid Method for multiplication. 2. To compare the achievement of students taught using the BDG Method and traditional multiplication methods. 3. To analyze the effect of the BDG Method on students' computational speed and accuracy.

## IV. Hypotheses

- **$H_0$:** There is no significant difference in multiplication achievement between students taught using the BDG Method and those taught using traditional methods.
- **$H_1$:** There is a significant difference in multiplication achievement between students taught using the BDG Method and those taught using traditional methods.

## V. Description of the Base Deviation Grid (BDG) Method

Unlike conventional base-based multiplication techniques, the BDG Method systematizes the treatment of numerical deviations through a clearly defined, grid-oriented framework that is specifically designed for effective classroom instruction and learner engagement.

The BDG Method operates by selecting an appropriate numerical base and representing the given multiplicands as positive or negative deviations from that chosen base, thereby simplifying the multiplication process through structured decomposition.

**Algorithm**

Let

$$A = B + a, \;\; C = B + c$$

Where

- $B$ is a convenient base (power of 10 or multiple of 50)
- $a, c$ are positive or negative deviations

**The multiplication is carried out as follows: -**

**Step 1:** Left Part (Linear Adjustment)

$$L = B + (a + c)$$

**Step 2:** Right Part (Deviation Product)

$$R = a \times c$$

**Step 3:** Final Result

$$A \times C = L \times B + R$$

Or $$(B + a) \times (B + c) = B \times [B + (a + c)] + a \times c$$

This explicit separation of steps reduces cognitive load and enhances conceptual clarity.

**Example 1: Two-Digit Numbers Near a Power Base**

Consider the multiplication: $104 \times 97$

Choose the base $B = 100$

Deviations: $a = +4$, $c = -3$

Left Part: $100 + (4 - 3) = 101$

Right Part: $4 \times (-3) = -12$

Final Product: $(101 \times 100) - 12 = 10088$

Hence, $104 \times 97 = 10088$

**Example 2: Mid-Base Case (Non-Power Base Application)**

Consider the multiplication: $48 \times 53$

Choose the base $B = 50$

Deviations: $a = -2$, $c = +3$

Left Part: $50 + (-2 + 3) = 51$

Right Part: $-2 \times 3 = -6$

Final Product: $(51 \times 50) - 6 = 2544$

Hence, $48 \times 53 = 2544$

## VI. Research Methodology

### *6.1 Research Design*

A quasi-experimental pre-test–post-test control group design was adopted for the study.

### *6.2 Sample*

- Population: Grade IX students
- Sample Size: 60 students
- Experimental Group: 30 students (BDG Method)
- Control Group: 30 students (Traditional Method)
- Sampling Technique: Purposive sampling

### *6.3 Tools Used*

A researcher-constructed achievement test on multiplication consisting of 20 items was used. The maximum score was 40 marks.

### *6.4 Rubric for Assessment*

Students' performance was assessed using a standardized rubric focusing on conceptual understanding, procedural accuracy,
speed, and final answer accuracy.

### *6.5 Reliability and Validity*

- Content validity ensured through expert review
- Reliability coefficient: 0.82 (Split-half method)

## VII. Procedure of Data Collection

1. Administration of pre-test to both groups
2. Teaching intervention for two weeks
3. Administration of post-test
4. Scoring using achievement test and rubric
5. Compilation and analysis of data

## VIII. Statistical Analysis

The collected data were analyzed using: - Mean and Standard Deviation - t-test for comparing post-test scores

## IX. Results and Discussion

### *9.1 Analysis of Pre-test Scores*

To establish group equivalence before the instructional intervention, pre-test scores of both the experimental and control groups
were analyzed.

**Table 1: Pre-test Scores of Experimental and Control Groups**

| Group | N | Mean | Standard Deviation |
|---|---|---|---|
| Experimental (BDG) | 30 | 18.40 | 3.12 |
| Control (Traditional) | 30 | 18.10 | 3.05 |

The mean scores of both groups were nearly equal, indicating that the two groups were comparable in their multiplication achievement prior to the experiment. The small difference in mean scores was found to be statistically insignificant, confirming baseline equivalence.

### *9.2 Analysis of Post-test Scores*

After the two-week instructional intervention, a post-test was administered to both groups.

**Table 2: Post-test Scores of Experimental and Control Groups**

| Group | N | Mean | Standard Deviation |
|---|---|---|---|
| Experimental (BDG) | 30 | 31.80 | 3.46 |
| Control (Traditional) | 30 | 25.20 | 3.28 |

The experimental group showed a substantially higher mean score compared to the control group, indicating a positive impact of the BDG Method on students' multiplication achievement.

### *9.3 t-test Analysis of Post-test Scores*

A t-test was applied to determine whether the difference between the post-test mean scores of the two groups was statistically
significant.

**Table 3: t-test Comparison of Post-test Scores**

| Groups Compared | Mean Difference | t-value | Level of Significance |
|---|---|---|---|
| Experimental vs Control | 6.60 | 6.12 | Significant at 0.05 level |

The calculated t-value (6.12) was greater than the critical t-value at the 0.05 level of significance, leading to the rejection of the null hypothesis. This confirms that the difference in achievement between the two groups was statistically significant.

### *9.4 Discussion of Findings*

The analysis of results clearly indicates that students taught using the Base Deviation Grid (BDG) Method performed significantly better than those taught using traditional multiplication methods. The higher mean scores of the experimental group suggest improved conceptual understanding, procedural accuracy, and computational speed.

Classroom observations revealed that students in the experimental group were more confident in selecting suitable bases and handling deviations, which reduced calculation errors. The structured nature of the BDG Method helped students organize their thinking and minimized cognitive overload during multi-step multiplication.

The findings are consistent with constructivist learning theory, which emphasizes active engagement and conceptual clarity. The results also support previous research advocating the use of mental-math strategies to enhance number sense and flexibility in computation.

Thus, the BDG Method proves to be an effective instructional strategy for improving multiplication skills at the secondary school level.

## X. Educational Implications

- The BDG Method can be effectively integrated into secondary mathematics classrooms.
- It supports conceptual learning and reduces dependence on rote procedures.
- Teachers can use the method to strengthen students' mental computation skills.

## XI. Limitations of the Study

- The sample size was limited to one school.
- The duration of the intervention was relatively short.
- Long-term retention was not measured.

## XII. Conclusion

The Base Deviation Grid Method provides a systematic and pedagogically sound approach to multiplication. The study demonstrates that structured mental-math strategies can significantly improve students' achievement and computational efficiency. Further research may explore its applicability across different grade levels and mathematical operations.

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