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Using the Lattice Method to help Basic Six (6) Pupils of Zogbeli Primary School in Ghana to understand the Concept of Multiplying Multi-digit Multiplicands

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ABSTRACT
This study emerged as a result of the inability of Basic Six (6) at Zogbeli Primary School pupils in Tamale, Northern Region Ghana to understand the concept of multiplying multi-digit multiplicands. To address this problem, the action research methodology was used to provide an immediate solution. A simple random sample of 45 pupils from a total of 90 pupils of a mixed class of P.6A and P.6B was chosen to participate in the study. A Pre-test consisting of 10 test items was administered to assess the pupils' initial understanding of the concept. The results showed that the majority of the pupils scored poorly, with a mean score of 1.51 and a standard deviation of 0.91. An intervention using the lattice method for five days was then implemented. The lattice method is a hands-on learning method that involves both physical movement and mental engagement. It was hypothesized that this method would help the pupils to develop a deeper understanding of the concept of multiplying multi-digit multiplicands. After the three-day intervention, a Post-test was administered to assess the pupils' understanding of the concept of multiplying multi-digit multiplicands and also to assess how effective the intervention was in the study. The results showed a significant improvement, with a mean score of 8.11 and a standard deviation of 2.54. Additionally, 93.4% of the pupils scored above the average mark of 5. The findings of this study suggest that lattice technology is an effective method for teaching the concept of multiplying multi-digit multiplicands. This method is engaging and easy to understand, and it can help pupils develop a deeper understanding of the mathematical concepts involved. In conclusion, the use of lattice technology has improved the learning experiences of Basic Six pupils at Zogbeli Primary School. Pupils now have a practical method for solving multi-digit multiplication problems, and they have a better understanding of the mathematical concepts involved.

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INTRODUCTION
Multiplication is a cornerstone of mathematical operations that paves the way for more complex mathematical concepts. Mastering multiplication is essential for students to thrive in diverse fields, including science, engineering, finance, and everyday life. However, many pupils struggle with multiplication, especially when dealing with multi-digit multiplicands. While traditional long multiplication is effective, it can be tedious, error-prone, and less engaging for some students.

In the realm of mathematics education, primary school pupils' proficiency in multiplication forms a fundamental building block of their mathematical journey. During the author's contact with basic six pupils at the Zogbeli Primary School, one of the model schools under the supervision of Tamale College of Education in Ghana, it became clear that pupils had trouble multiplying multi-digit multiplicands, a skill crucial for their future academic success. One promising approach to address this challenge is the lattice method. The lattice method is an alternative multiplication algorithm that introduces a visual and structured approach to solving multiplication problems involving multi-digit numbers.

While research has shed light on the efficacy of the lattice method in diverse educational settings, its effectiveness within the unique context of Zogbeli Primary School remains unexplored. The school's diverse learning environment, resource constraints, and varying pupil readiness levels necessitate a context-specific examination of the lattice method's applicability and impact. The reputable National Council of Teachers of Mathematics in the USA,[1] referenced in Kin, et al., states that "sense-making may be seen as creating an understanding of a situation, context, or idea by integrating it with current knowledge or prior experience."[2] For both scholars and practitioners, enhancing the calibre of mathematics teaching within classrooms, schools, and development agenda jurisdictions is a critical issue.

According to Even and Ball, school administrators in several nations are under pressure to increase students' opportunities for learning mathematics, algorithms, and definitions.[3] Practical knowledge is defined as "knowledge of measures and actions for recognising mathematical elements”. The term "conceptual knowledge" describes an understanding of the fundamental principles of mathematics. This knowledge is full of connections and requires a grasp of facts, definitions, and mathematical ideas. Or to put it another way, comprehending mathematics requires both intellectual and practical knowledge. The teaching of both theoretical and practical knowledge must be included in the teaching of mathematics. Many areas of mathematics, including fractions and functions, are characterized by multiplication-based reasoning. There is agreement that learning multiplicative thinking is crucial. Normally, multiplication is taught as dequeue, but when it is expanded to teach multi-digit numbers and decimals, a broader understanding of multiplication is needed.[4]

This study aims to address this gap by delving into the specific dynamics of Zogbeli Primary School, evaluating the method's suitability and effectiveness in this distinct educational context. The main goal of this study is to examine the effectiveness of incorporating the lattice method as an instructional approach for basic six (6) pupils at Zogbeli Primary School, focusing on their proficiency in mastering the multiplication of two multi-digit multiplicands.The following questions underlie the study:

a. Does the application of the lattice method enhance the multiplication performance of basic six (6) pupils at Zogbeli Primary School as compared to the traditional long multiplication method?
b. What are the perceptions of both teachers and pupils regarding the utilization of the lattice technology in the teaching of multiplication?

The subsequent sections of this study will be structured as follows: A comprehensive review of existing research on the lattice method and its applications in diverse educational settings, highlights areas where further investigation is needed, particularly in the context of Zogbeli Primary School; A detailed description of the research design, data collection methods, and the rationale behind selecting the lattice method as a focal teaching strategy; An interpretation of the results, drawing meaningful conclusions about the effectiveness of the lattice method in improving multiplication performance among basic six pupils at Zogbeli Primary School; A summary of the key findings of the study, acknowledging any limitations and suggesting directions for future research. Recommendations for educational practices based on the study's findings will also be provided.

LITERATURE REVIEW

As educators continually seek effective and engaging teaching strategies, the Lattice method presents itself as a potential solution to overcome the challenges associated with traditional multiplication instruction. Nevertheless, the actual situation is that most fourth or fifth-grade students have not fully mastered addition and subtraction facts, and students in upper primary grades and beyond lack proficiency in their multiplication facts.[5] In a study utilizing a quasi-experimental method with intact classes, Mocorro selected two classes of second-

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[1] National Council of Teachers of Mathematics, “Focus in High School Mathematics: Reasoning and Sense Making,” https://www.nctm.org/Standards-and-Positions/Focus-in-High-School-Mathematics, 2009.
[2] Kin Eng Chin, Fui Fong Jiew, and Elvent Taliban, “Conceptions in Making Sense of Multiplication,” *EURASIA Journal of Mathematics, Science and Technology Education* 15, no. 12 (July 5, 2019), https://doi.org/10.29333/ejmste/105480.
[3] R. Even and D. L. Ball, *The Professional Education and Development of Teachers of Mathematics: The 15th ICMI Study* (New York: Springer, 2010).
[4] Kerstin Larsson, “ Students’ Understandings of Multiplication ” (Stockholm University, 2016).
[5] Alex Mbonabi Ilukena, Christina Nyarai Utete, and Chosi Kasanda, “Strategies Used by Grade 6 Learners in the Multiplication of Whole Numbers in Five Selected Primary Schools in the Kavango East and West Regions.,” *International Education Studies* 13, no. 3 (2020): 65–78.

year education students as the subjects. Pretests and posttests were administered to both groups.[6] The findings demonstrated that students instructed with the Lattice technology in Multiplying Polynomials exhibited significantly superior performance compared to those taught using the conventional vertical method of multiplication. In another study by Anita involving 55 sixth-grade students, it was determined that the Lattice technology effectively improved multiplication test scores.[7] The recommendation arising from this research is to widely implement the Lattice technology in schools. These findings have implications for students, teachers, and researchers, influencing aspects such as preparedness, planning, and the execution of multiplication teaching and learning. Anita suggests that teachers incorporate diverse and engaging teaching methods, including enjoyable ones, to foster increased mathematics achievement among students. In Nigeria, Adeyinka and Olatunde conducted a study involving primary school students, demonstrating that the lattice method was an effective tool for teaching multiplication, leading to significantly better performance compared to traditional methods.[8]

The Concept of Multiplication

The four fundamental activities in mathematics are addition, subtraction, division, and multiplication. Multiply in mathematics refers to the continual addition of sets of identical sizes. 3 + 3 is equivalent to 2 x 3 as we can see. The outcome of two-number multiplication is referred to as the "product."The multiplier is the quantity that multiplies the number of such equal portions by the multiplicand, the number of items in each group. In our example, 3 is the multiplicand, 2 is the multiplier, and 6 is the result.The process of multiplying two or more integers in mathematics is used to determine the product of the numbers. It is a fundamental operation in mathematics that is frequently utilized in everyday life. When combining groups of similar sizes, multiplication is utilized. The fundamental concept of repeatedly adding the same number is represented by the process of multiplication. The results of multiplying two or more integers are known as the products, and the factors that are used in the multiplication are referred to as the variables. The process of repeatedly adding the same number is made simpler by multiplication. One-digit numbers can be multiplied simply by utilizing the times tables when solving multiplication problems, however, for bigger numbers, we divide the numbers into columns using their corresponding place values, such as ones, tens, hundreds, thousands, and so on. Multiplication is based on two opposing assumptions, according to the conclusions of Park and Nunes' study on the examination of the two possibilities using an intervention approach.[9] The first hypothesis states that our understanding of repeated addition serves as the foundation for the idea of multiplication, Contrary to the second theory, which claims that continuous addition is just a processing technique and that the multiplicative idea is irrelevant.

What is the Lattice Multiplication Method?

The lattice multiplication method, a visually engaging alternative to traditional long multiplication, utilizes a grid-like structure to break down the multiplication process into smaller, more manageable steps.[10] This approach can be particularly beneficial for students struggling with traditional methods due to its emphasis on place value visualization and step-by-step decomposition.[11] The method of lattice multiplication was invented in India in the Tenth Century. This approach, which Fibonacci later embraced in the 14th century, appears to be taking over as the "go-to" strategy for instructing elementary school kids on how to multiply two numbers where at least one of them is a two-digit figure or higher. Because this method arranges the very same algorithm that was most likely learnt in elementary school into a box, it is also frequently referred to as the "box method." This method can be applied to any kind of multiplication problem by using the Pythagorean theorem. In addition to instructing students on multiplying two larger numbers, this method also provides them with an opportunity to refine their organizational skills and develop the ability to ascertain the place value of a given number.

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[6] R. Mocorro, "Lattice Method In Polynomial Multiplication," *Asian Academic Research Journal of Multidisciplinary* 4, no. 8 (2017).
[7] Anita Rebekawati, "The Effectiveness of Lattice Multiplication for Improving Multiplication Test Scores among Grade Six Pupils in Katsina State, Nigeria," *International Journal of Research in Education and Development* 6, no. 1 (2017): 45–51.
[8] R. O. Adeyinka and F. O. Olatunde, "The Effectiveness of the Lattice Method in Teaching Multiplication of Whole Numbers to Primary School Pupils in Ibadan, Oyo State, Nigeria.," *British Journal of Education* 2, no. 4 (2012): 12–21.
[9] J. Park and T. Nunes, *The Development of the Concept of Multiplication? Department of Psychology* (Oxford: Oxford Brookes University, 2001).
[10] Thompson and Davis, *Teaching Mathematics Through Play in the Early Years* .
[11] Aydogdu and Aydogdu, "The Effect of Using the Lattice Method on Students' Achievement in Multiplication."

Lattice Method of Multiplication

The following steps are followed:

i) The lattice method, which uses a rectangle with smaller rectangles and triangles inside of it, is a helpful visual way to perform multiplication.

ii) Although the steps are quite similar to those taken when multiplying with the vertical algorithm, one can complete all of the adding in one phase and all of the multiplication in a separate phase.

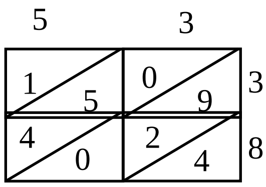
A solution to 53 x 38 using this approach serves as an illustration.

Step 1: Set up your rectangle to depict the multiplication of two-digit numbers. To represent this, each side is two units long. One number is written at the top and on the right side.

Step 2: Let's also create triangles by cutting each portion in half diagonally.

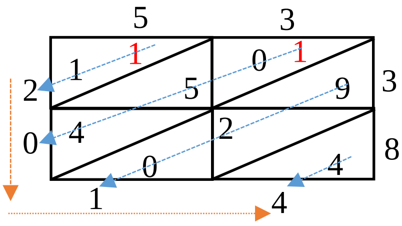
Step 3: Let us begin by multiplying 3 x 3. Note that the filling of the rectangle is done anticlockwise, units are written in the down triangles and tens in the up triangles of each smaller rectangle. So, the answer (9) is put in the down triangle of the first smaller rectangle on the right and zero (0) in the up triangle.

Step 4: We continue multiplying until there is a number in each triangle of our lattice. Keep in mind that the top triangle in each area indicates the number in the tens place, while the triangle in the bottom section indicates the value in the one's place. When finished, the lattice has this appearance.



Step 5: We can begin adding now. We begin by adding the numbers along the diagonals, as shown by the blue arrows, beginning with the triangle in the bottom right corner. As we proceed to the next diagonal to the left, it will be our tens place from this corner, which is currently our one (and so on).

As we add, we advance in the direction indicated by the arrows below. For example, because 9 + 2 + 0 = 11, we will write 1beneath the triangle as pointed by the blue arrowhead and carry the representing tens (10) to the hundreds place, thus the top right triangle written in red colour resulting in adding 1+0+5+4 = 10. Zero (0) is written as pointed by the blue arrowhead and carries the 1 representing hundreds (100) to the thousands place, resulting in adding 1+1 = 2. The 2 representing thousand is written as pointed by the blue arrowhead. Our final answer is obtained by arranging the numbers along the vertical left and the bottom following the red arrows. 53 x 38 = 2,014.



Why The Choice of the Lattice Multiplication Method?

It is vital to recognize that the lattice multiplication method is not a complete substitute for the conventional long multiplication method, even though it has gained popularity as a possible substitute. Each approach has advantages and disadvantages, and the best approach will often rely on the particular circumstances and requirements of the students. Based on scholarly sources, the following is an explanation of the rationale behind the potential selection of lattice multiplication over the conventional long method.

Visual Representation: Thompson and Davis suggest that the lattice method aids in understanding the place value and partial products used in multiplication.[12] This is achieved by providing students with a clear and organized visual representation of the process. The visual element can be particularly advantageous for students

[12] A. Thompson and R. Davis, *Teaching Mathematics Through Play in the Early Years* , 3rd ed. (Routledge, 2014).

who struggle with abstract concepts or find it challenging to grasp the linear arrangement of the long multiplication method.[13]

Reduced Cognitive Load*:* There is a chance that the lattice method will lessen the mental strain that comes with multi-digit multiplication. This is so that it requires less algorithm memorization and breaks the problem down into smaller, more manageable steps.[14] According to Jordan and Rittle-Johnson, this can be beneficial for students who have trouble with working memory or who find traditional long multiplication to be mentally taxing.[15]

Error Identification and Correction: The lattice method's visual layout makes it easier to identify and fix mistakes made by students when calculating. According to Brown and Jones, errors are more obvious in the grid structure than in the long method's linear format.[16] Because of the grid structure's improved visibility, students can identify and correct their own mistakes, which promotes increased self-monitoring and independent learning.

Conceptual Understanding: There is a claim that the lattice method has greater potential for developing a conceptual understanding of multiplication, even though practice with both approaches can lead to procedural fluency. This is explained by the visual representation, which lets students see how the different digits work together to create the finished product. As a result, it makes place value and distributive property easier to understand, according to Anita.[17]

Teaching Perspectives in The Classroom

"If you tell me, I'll forget. If you show me, I might remember. If you include me, I'll comprehend."[18] Evaluation of the Exploration method, the teacher must encourage and cultivate an environment of active learning where students actively participate in and take control of the learning process. This lessens the students' reliance on the teacher. Additionally, it is important to promote the development of innovative methods that call for more complex thought processes. Nearly all teachers encourage their pupils to "take responsibility for learning."[19] In the exploration learning mode, the student must actively participate in many decisions regarding what, how, and when it is to be learned. They must play a significant part in these decisions.

The learner is supposed to investigate examples and through them "find" the rules or concepts that are to be learned rather than having the content "told" to them by the teacher. There is a persistent argument about how much a teacher should assist a student and how much the student should assist themselves, according to many, which the exploration learning versus expository debate is merely rehashing.[20] Students actively create the meaning of the concepts they acquire in mathematics through individual re-organization, re-presentation, and re-construction as well as social negotiating with peers, elders, and teachers.[21]

Discovery instead of passively absorbing information as if it were an empty vessel to be filled by the teacher, learning is an active, hands-on method of learning where the student actively participates in the learning process. It is a method of teaching whereby students engage with their surroundings by investigating and handling items, debating issues and controversies, or conducting experiments. It is backed by constructivist and cognitive psychology theories of learning and understanding. [22]

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[13] M. Aydogdu and H. Aydogdu, "The Effect of Using the Lattice Method on Students' Achievement in Multiplication," *International Journal of Mathematical Education* 4, no. 2 (2013): 106–12.

[14] A. Smith, B. Johnson, and C. Williams, "Visualizing Success: The Lattice Method in Elementary Mathematics Education," *Journal of Mathematics Education* 20, no. 3 (2015): 123–45.

[15] N. C. Jordan and B. Rittle-Johnson, "The Role of Visual-Spatial Processing in Early Mathematics Development," *Developmental Psychology* 45, no. 5 (2009): 1489–1502.

[16] R. Brown and M. Jones, " Multiplication Pedagogy: A Comparative Study of Lattice and Traditional Methods ," *Journal of Educational Research* 42, no. 2 (2017): 189–211.

[17] Rebekawati, "The Effectiveness of Lattice Multiplication for Improving Multiplication Test Scores among Grade Six Pupils in Katsina State, Nigeria."

[18] Confucius; 450 BC.

[19] Mysore Narayanan, "Assessment of Discovery Approach," in *2012 ASEE Annual Conference & Exposition Proceedings* (ASEE Conferences, 2012), 25.225.1-25.225.27, https://doi.org/10.18260/1-2--20985.

[20] J. Bruner, *Child's Talk: Learning to Use Language.* (New York: Norton Center for Elementary Mathematics and Science Education The University of Chicago. , 1983).

[21] S. Belbase, "Construction of Mathematical 'Self' as an Edge Behaviour," in *Program and Abstracts: First International Conference on Transformative Education Research and Sustainable Development*, ed. R.K. Dhakal et al. (Dhulikhel, Nepal: Kathmandu University School of Education, 2016), 145–46.

[22] Brown E., "Discovery Learning in the Classroom," https://www.researchgate.net/publication/305174476, 2016.

THEORETICAL FRAMEWORK

Multiplication serves as a crucial mathematical operation vital for cultivating pupils' numerical and computational fluency. Nevertheless, numerous sixth-grade students face challenges in mastering multi-digit multiplication, particularly with conventional methods like long multiplication. This study explores the efficacy of the Lattice Method in assisting sixth-grade pupils in calculating the product of two multi-digit multiplicands. This study draws upon several theoretical frameworks to understand the impact of the Lattice Method on pupils learning.

i. **Constructivism:** Piaget, in one of his findings, stated that students actively construct knowledge through interactions with their environment and peers.[23] The Lattice Method, with its visual and interactive nature, provides a concrete learning environment facilitating knowledge construction.

ii. **Cognitive Load Theory**

Working memory limitations can hinder learning complex concepts.[24]The Lattice Method breaks down multi-digit multiplication into smaller, more manageable steps, reducing cognitive load and promoting efficient information processing.

iii. **Dual Coding Theory**

Learning is enhanced when information is presented in both visual and verbal formats.[25]The Lattice Method combines visual representations and mathematical symbols, engaging both visual and verbal learning pathways.

iv. **Zone of Proximal Development (ZPD)**

Learning occurs best in the ZPD, where students receive appropriate support to acquire new skills.[26] Vygotsky defines the ZPD as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers."[27] The Lattice Method acts as a scaffold, providing support for pupils to solve problems and develop independent mastery of multiplication.

METHODOLOGY

This study will utilize a mixed-methods approach that integrates both quantitative and qualitative data collection methodologies. The quantitative facet will encompass a pre-test and post-test design, facilitating a comparison of the multiplication performance of pupils before and after the intervention. Complementing this, the qualitative aspect will involve conducting unstructured interviews with both teachers and pupils to garner their insights into the efficacy of the lattice technology. The chosen research design for this study is Action research. This design was selected because the issues at hand must be addressed immediately in the classroom if learning is to advance. It also covers modest interventions appropriate for one-class settings, which was the situation used for the study. Action research, in particular, is a planned investigation conducted by a teacher in the hopes that the results will inform and modify future practices. Engaging in action research empowers educators to recognize and explore challenges within their immediate environment, such as issues like low student engagement, ineffective teaching methods, or insufficient learning materials. Through the collection of data and reflective practices, they can formulate and apply solutions grounded in evidence, specifically tailored to address the unique needs of their students and educational setting.[28] Participating in action research is pivotal for creating knowledge about successful teaching and learning methods. Educators, through research in their classrooms, can offer valuable insights to the educational community and exchange experiences with their peers. This collaborative approach to knowledge generation has the potential to enhance pedagogical practices and elevate student outcomes across various educational settings.[29] According to Fisher & Phelps, "Action Research is an imposed scholarly paradigm resulting in action for a specific situation offering faculty immediate benefits by improving his or her

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[23] Jean Piaget and Margaret Trans Cook, *The Development of Object Concept* (Basic Books, 1954).
[24] A. D. Baddeley and C. J. Hitch, "Working Memory," in *The Psychology of Learning and Motivation*, ed. G. A. Milton and W. E. Bower, vol. 8 (Cambridge, Massachusetts, : Academic Press, 1974), 47–89.
[25] A. Paivio, *Mental Representations: A Dual Coding Approach.* (Oxford: Oxford University Press., 1986).
[26] L. S. Vygotsky, *Mind in Society: The Development of Higher Psychological Processes* (Cambridge: Harvard University Press, 1978).
[27] Vygotsky, *Mind in Society: The Development of Higher Psychological Processes*, 6.
[28] Marilyn Cochran-Smith and Elizabeth Stringer Keefe, "Strong Equity: Repositioning Teacher Education for Social Change," *Teachers College Record* 124, no. 3 (2022): 9–41.
[29] Colin Lankshear and Michele Knobel, *A Handbook for Teacher Research* (McGraw-Hill Education (UK), 2004).

teaching and giving explicit documentation for meeting their educational obligations as required by standards."[30] It aims to record the pedagogical context, changing processes, learning that results, and thinking of faculty members.

Population

The target population for this study was forty-five (45) pupils at Zogbeli Primary School in the Tamale Metropolis and the two class teachers of the two Basic six (6) classes. The population size was ninety (90) pupils.

Sampling Procedure

Simple Random Sampling is a method of selecting a sample from a population where each individual in the population has an equal chance of being included in the sample. This method is chosen to ensure the sample is representative of the population. A random sample of participants was selected by drawing from a box containing 90 slips of paper, 45 marked YES and 45 marked NO. Participants shuffled the slips before drawing. Individuals who drew a YES slip (45 total) constituted the study sample. This number is the Ghana Education Service's standard for a classroom (GES). In this situation, individuals are selected entirely by chance, and each member of the population has an equal probability of being selected. One approach to achieving a random sample involves assigning a unique number to each person in the population and choosing individuals to include based on a table of randomly generated numbers.[31]

Data Collection

The following data collection instruments were used to collect data for this research: observation, unstructured interview, pre-test and post-test. In the realm of data collection, observation stands out as a direct approach. Through watchful eyes and meticulous recording, researchers gather firsthand information about the behaviours, events, or phenomena they seek to understand. Unstructured interviews stand apart from their structured ones as they wield a unique power to unearth unexpected truths and elevate research validity. By casting aside rigid question lists, they invite participants on a journey of self-discovery, freely expressing thoughts, feelings, and experiences that organically weave a tapestry of authentic data. In essence, unstructured interviews become catalysts for genuine expression that amplifies the trustworthiness and depth of research findings by allowing participants to be their truest selves. A pre-test provides a baseline measurement of the variables under investigation before any interventions or treatments are implemented. This baseline helps researchers understand the initial status or conditions of the study participants. The post-test is a crucial component in research, serving the primary purpose of assessing the impact of an intervention or treatment. By comparing pre-and post-test scores, researchers can quantify the magnitude of change and determine whether the intervention resulted in significant improvements in knowledge, skills, attitudes, or behaviour. This evaluation is essential for establishing the effectiveness of the intervention and drawing conclusions about the observed changes attributable to the experimental manipulation.

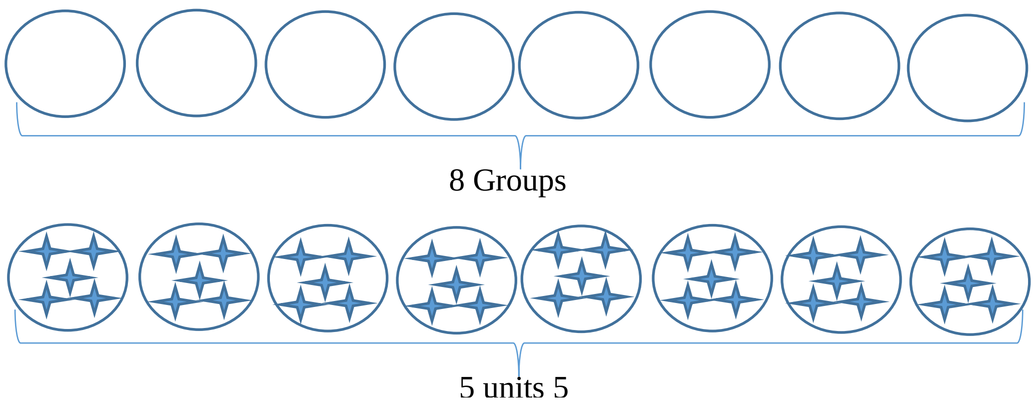
Intervention Activities

The intervention was carried out during the usual contact hours for mathematics periods after obtaining authorization from the school administration. The entire activity lasted for five days.

First day's Activities

The pupils were put into eight (8) groups of five (5) pupils each. A review of their previous knowledge of multiplication was sought for using the "**Scale** x **Uni**t" approach. For example, 8 x 5: the scale is 8 which determines the number of groups to be formed and the unit is 5 which also determines the number of units in each group.

[30] K. Fisher and R. Phelps, "Recipe or Performing Art? Challenge Convention for Writing Action Research Theses," *Action Research* 4, no. 2 (2006): 143–64.
[31] Y. Ben-Shlomo, S. Brookes, and M. Hickman, *Lecture Notes: Epidemiology, Evidence-Based Medicine and Public Health* , 6th ed. (Oxford: Wiley-Blackwell, 2013).

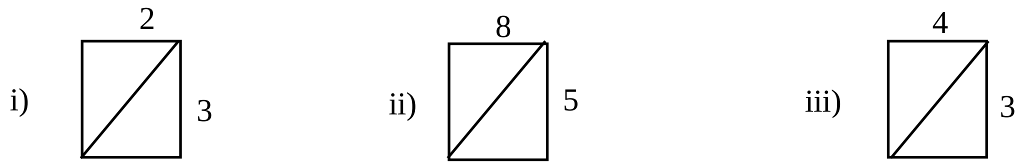


This activity can be interpreted as 8 x 5 stars, thus, 8 groups of 5 stars totalled 40 stars. Therefore, 8 x 5 = 40. The next activity was to introduce the lattice multiplication technique to solve the following cases:

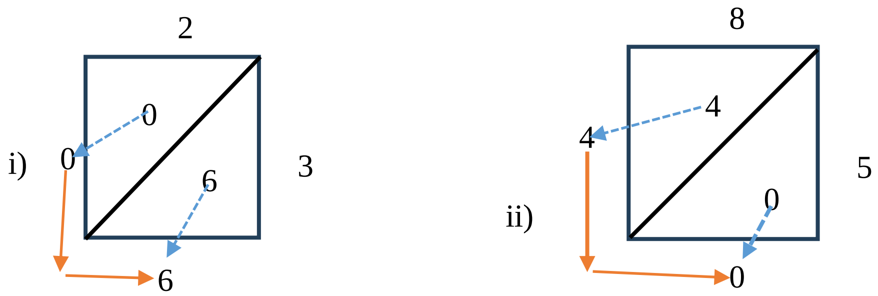
One-Digit by One-Digit Multiplication

For example, solve the following i) 2 x 3   ii) 8 x 5   iii) 4 x 3

First step: Pupils were guided to draw a rectangle and split it into two triangles diagonally, placing the multiplicand on top and the multiplier by the right side as shown below.



Second step: Pupils were instructed to do the multiplication and place the answer in the bottom triangle and put zero (0) in the top triangle if only the answer is a single digit. But if it is a double-digit number, the tens digit is put at the top triangle. After which, they are once again asked to add all the numbers below the diagonal and place the answer below the rectangle and also add all the numbers above the diagonal and place the answer on the left side of the rectangle as illustrated below.



Third step: Pupils are guided to write the final answers to these problems by writing the number on the left side of the rectangle first followed by the number at the bottom as directed by the brown arrow and these two numbers put together represent the answer or product of the multiplication.

i) 2 x 3 = 06 = 6   ii) 8 x 5 = 40   iii) 4 x 3 = 12.

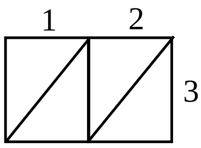
Second Day's Activities

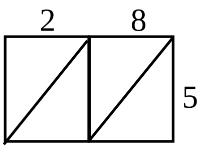
Two-Digits by One-Digit Multiplication

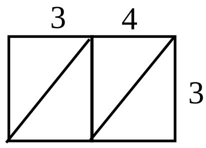
For example, solve the following i) 12 x 3   ii) 28 x 5   iii) 34 x 3

This concept is one step more advanced than day one's concept.

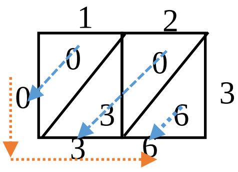
First step: Pupils were guided to draw a rectangle, divide the rectangle into two equal parts and then split it into four triangles diagonally, placing the multiplicand on top and the multiplier by the right side.

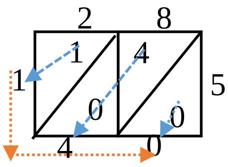
i) 

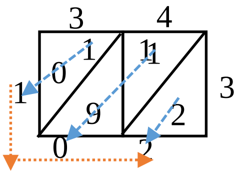
ii) 

iii) 

Second step: As usual, pupils were instructed to do the multiplication this time along the two columns, place the answers in the bottom triangles and put zero (0) in the top triangles if only the answer is a single digit. But if it is a double-digit number, the tens digit is put at the top triangles. After which, they are once again asked to add all the numbers below the diagonal as directed by the blue arrows and place the answers below the rectangle, but if an answer is a double-digit number, the unit digit is written and the tens digit is written at the top triangle. Also, add all the numbers above the diagonal (i.e., top triangle) and place the answers on the left side of the rectangle as directed by the red arrow.

i) 

ii) 

iii) 

Third step: Pupils are guided to write the final answers to these problems by writing the number on the left side of the rectangle first, followed by the bottom numbers as directed by the brown arrows and these three numbers put together represent the answer or product of the multiplication.

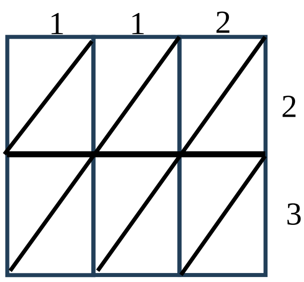
i) 12 x 3 = 036 = 36   ii) 28 x 5 = 140   iii) 34 x 3 = 102.

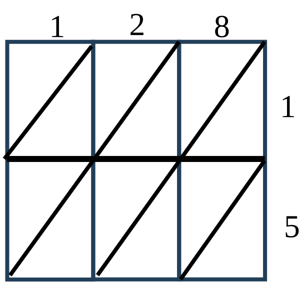
Third Day's Activities

Three-digits by two-digits Multiplication

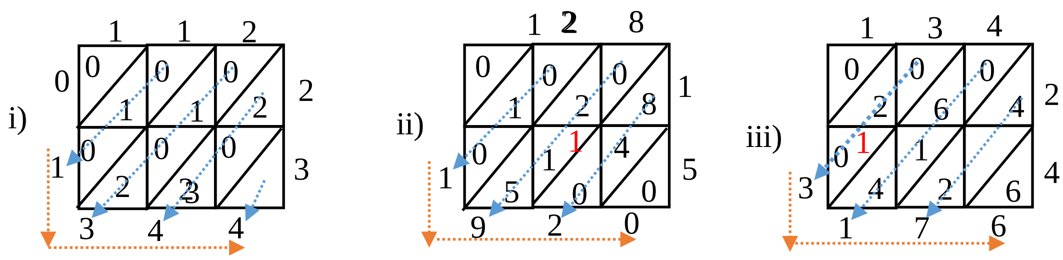
For example, solve the following i) 112 x 23   ii) 128 x 15   iii) 134 x 23

First step: Pupils were guided to draw a rectangle and divide the rectangle into six equal parts and then split it into twelve triangles diagonally, placing the multiplicand on top and the multiplier by the right side.

i) 

ii) 

Second step: As usual, pupils were instructed to do the multiplication this time along the three columns and place the answers in the bottom triangles and put zero (0) in the top triangles if only the answer is a single digit. But if it is a double-digit number, the tens digit is put at the top triangles. After which, they add all the numbers below the diagonal and place the answers below the rectangle and also add all the numbers above the diagonal and place the answers on the left side of the rectangle as directed by the red arrow.

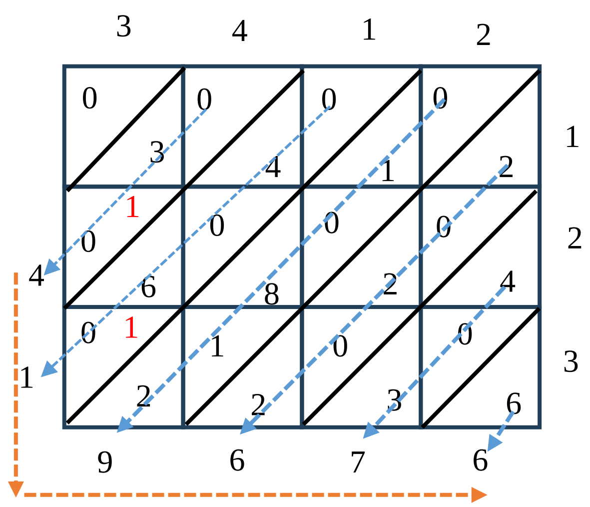


Third step: Pupils are guided to write the final answers to these problems by writing the number on the left side of the rectangle first, followed by the bottom numbers and these numbers put together represent the answer or product of the multiplication.

i) 112 x 23 = 02576 = 2576 ii) 128 x 15 = 01920 = 1920 iii) 134 x 23 = 03082 = 3082

Third Day's Activities

Four-digits by three-digits Multiplication by this stage, the pupils have come to realise that the multiplicand determines the columns and the multiplier also determines the rows of the lattice. For example, 3412 x 123, the lattice would have 4 columns and 3 rows.



As usual, pupils were guided to write down the answer or product following the direction of the brown arrow. Thus, 3412 x 123 = 419676.

Experiential action is emphasized as a beginning point for learning with young children in the works of Piaget, Bruner, and Liebeck, and Gifford reports that this strategy is also supported by neuroscientific research.[32] To help students develop such understanding, teachers need to design, adapt, or select worthwhile mathematical tasks for them to work with, interpret the responses that they give, and make instructional decisions based on the thinking that they reveal. Before identifying suitable learning opportunities for pupils, mathematics teachers must comprehend how the multiplication algorithm functions.[33]

RESULTS AND DISCUSSIONS

This research explored the efficacy of the lattice method, a visual and structured approach to multiplying multi-digit numbers, for assisting Basic Six (6th grade) pupils at Zogbeli Primary School in mastering multiplication. By employing this grid-based technique, the study aimed to improve students' comprehension and proficiency

[32] Helen Taylor, "1 How Children Learn Mathematics Andthe Implications for Teaching," *Learning and Teaching Mathematics 0-8*, 2013, 8.

[33] I. Whitacre and S. D. Nickerson, "Investigating the Improvement of Prospective Elementary Teachers' Number Sense in Reasoning about Fraction Magnitude," *Journal of Mathematics Teacher Education* 19, no. 1 (2016): 57–77.

in tackling complex multiplication problems, ultimately evaluating the method's potential as a valuable tool for boosting their understanding and performance in this crucial mathematical operation.

Findings from Observation

During the author's contact with basic six pupils at the Zogbeli Primary School, one of the model schools under the supervision of Tamale College of Education, it became clear that about ninety per cent (90%) of the pupils had trouble multiplying multi-digit multiplicands, a skill crucial for their future academic success.

Table 1: Findings from Unstructured Interview

Some of the Difficulties Faced By Pupils	Frequency	Per cent (%)
i. Difficulty with Place value	42	93.3
ii. Reliance on Memorization	35	77.8
iii. Lack of Visual Representation	40	88.9
iv. Need for Different Strategies	41	91.1
v. Need for Individualized Support	38	84.4

From Table 1, it can be seen that 93.3% of the pupils lack the concept and understanding of place value. One of the pupils boldly said "Sometimes I get confused with the place value when multiplying big numbers. I can't keep track of the zeros and where they should go in the final answer." Place value stands as the invisible architect behind the successful multiplication of multi-digit numbers. It meticulously assigns positional significance to each digit, ensuring accurate and meaningful multiplication. Understanding and applying these principles are vital for breaking down the problem into smaller, readily manageable units called partial products. By mastering place value, students capture the precise contribution of each digit to the final answer, laying the foundation for a solid understanding of this fundamental mathematical operation. Reliance on memorization of the procedures multiplication without understanding why it is done that way was a challenge pointed out by 77.7% of the pupils i.e., "We mostly learn how to multiply by memorizing the tables. When the numbers get bigger, I can't remember all the combinations, and I don't know how to solve it without memorizing." 88.8% of the pupils said, "In class, we usually just write down the numbers and multiply them. I don't understand what's happening with the numbers, and I wish there was a way to see it better."

On the issue of using different strategies for the concept of multiplying multi-digit multiplicands, 91.1% of the pupils said, "I think there should be more than one way to learn multiplication. Not everyone learns the same way, and some of us need different strategies to understand it." Finally, on individual attention or support, 84.4% of them said, "I think some students need more individual help with multiplication than others. I would like to have more time with the teacher to ask questions and get extra practice."

These outcomes pushed for a further investigation into this problem the pupils were facing. Hence, a pre-test was carried out.

Analysis of Pre-test Results

It serves to identify individual differences in pupils' knowledge and skill levels, offering valuable insights that allow the researcher to tailor the intervention to address specific needs. This personalized approach ensures that each pupil receives appropriate support during the introduction of the lattice method. Furthermore, the pre-test serves as empirical evidence justifying the need for the intervention. If challenges in traditional multiplication are revealed during the initial assessment, it strengthens the rationale for introducing alternative methods like the lattice method, providing a clear and evidence-based justification for the instructional approach. Ten (10) test items made up the Pre-test, which was marked out of ten (10) marks.

Table 2: Results of the Pre-test

Marks out of 10	Frequency	Percentage (%)
0	13	29
1	10	22
2	12	27
3	8	18
4	2	4
5	0	0
6	0	0

7	0	0
8	0	0
9	0	0
10	0	0
Total	**45**	**100**

Table 2's findings revealed that the entire pupils representing 100% got less than half of the 10 marks from the Pre-test. This was a validation of the observation and the unstructured interview the researcher carried out with the pupils before the commencement of the Pre-test. Therefore, an intervention is needed immediately if these pupils are to make progress with mathematics.

Analysis of Post-test Results

The pre-test data serves as a valuable reference point for comparison with the post-test data. By comparing the results of the two tests, the researcher can quantify the impact of the lattice method and determine its effectiveness in improving pupils' multiplication skills. To gauge how the intervention affected pupils' understanding of multiplying multi-digit multiplicands using the lattice method, a post-test was given right away after the interaction. It sought to measure how effective the lattice method could be in helping pupils overcome their difficulty in multiplying multi-digit multiplicands. The test items matched those used in the previous test. The marking process and total marks allotted for the ten (10) questions were the same as for the pre-test (10 marks).

Table 3: Results of the Post-test

Marks out of 10	Frequency	Percentage (%)
0	0	0
1	0	0
2	0	0
3	0	0
4	1	2.2
5	2	4.4
6	4	9
7	8	18
8	10	22
9	9	20
10	11	24.4
Total	**45**	**100**

Source: Field Study 2022

The results of Table.3 showed a reverse of pupils' performance compared to the results of the Pre-test scores. Forty-two (42) out of the forty-five (45) pupils (i.e., representing 93.4 %) scored above the average mark of 5. The modification of the teaching and learning technique may be responsible for the improvement in the pupils' performance because the visual representation of the lattice method provides a clear and organized structure, breaking down the complexity of multi-digit multiplication. Emphasizing place value, the method aligns with the fundamental concept that the position of a digit determines its value in the overall product. The flexibility and adaptability of the lattice method make it suitable for diverse learning styles.

The Statistical Analysis of The Results

The results from the Pre-test and Post-test were recorded and analyzed using fundamental descriptive statistics, such as percentages. Additional statistical tools such as mean, standard deviation, Paired sample t-test and Eta-square value were used to further investigate the impact of the intervention to ensure the correctness and dependability of the outcomes of both the Pre-test and Post-test.

Mean and Standard Deviation of the Results

The results of Table 2 have the following as mean and standard deviation respectively (M = 1.51, SD = 0.91) which indicate that the majority of the pupils scored marks closer to 2 or less than the average mark of 5, as evidenced by the mean mark of 1.51 and standard deviation score of 0.91, on the other hand, demonstrating how close distributed the marks from the Pre-test is to the mean mark (i.e., 1.51) as a sign of poor performance. The results of the Table.3 too has the following as mean and standard deviation respectively (*M*= 8.11, *SD* = 2.54) which indicate that the majority of the pupils scored marks closer to 8 or greater than the average mark of 5, as evidenced by the mean mark of 8.11 and standard deviation score of 2.54, on the other hand, demonstrating how close distributed the marks from the Post-test is to the mean mark (i.e., 8.11) as a sign of tremendous performance.

Paired Sample T-test

The fact that the research design involves fewer individuals and permits an evaluation of change over time gives Paired samples t-tests an edge over other analytical methodologies (Chumney, F.). This statistical tool determines whether the mean change in scores between the two situations is statistically significant (i.e., Pre-test and Post-test).

Table 4: Paired Samples Statistics

	Mean	**Number of Pupils**	**Stand. Dev.**	**Standard Error mean**
Pre-test marks	1.51	45	0.91	0.136
Post-test marks	8.11	45	2.54	0.38

Discussion Summary

This research delved into evaluating the effectiveness of implementing the lattice method to enhance the multiplication skills of Basic Six (6th grade) pupils at Zogbeli Primary School, specifically in computing the product of two multi-digit numbers. The study commenced with pre-test assessments that revealed an initial poor performance among pupils, indicated by a mean score of 1.51 out of 5 and a standard deviation of 0.91. This narrow distribution highlighted a limited understanding of multi-digit multiplication before the lattice method intervention.

Post-intervention, the results from Table 3 displayed a significant improvement, with the mean score increasing to 8.11 and a standard deviation of 2.54. This shift toward a higher average and a broader distribution around the mean (8.11) showcased a substantial enhancement in proficiency, demonstrating the positive impact of the lattice method on pupils' multiplication skills.

The research provided compelling evidence for the success of the lattice method in improving the multiplication skills of Basic Six pupils at Zogbeli Primary School. The intervention effectively addressed initial challenges, leading to a noteworthy enhancement in performance, as evidenced by both the post-test results.

RECOMMENDATIONS

Based on the findings of the research on the effectiveness of the lattice method in helping Basic Six pupils at Zogbeli Primary School improve their multi-digit multiplication skills, several recommendations can be made:

1. The success of the lattice method in enhancing pupils' multiplication skills suggests that it should be integrated into the regular curriculum for Basic Six students. This would provide ongoing exposure and practice, reinforcing the skills acquired during the intervention.
2. Teachers play a crucial role in implementing instructional methods effectively. Providing professional development opportunities for educators to familiarize themselves with the lattice method and its application can contribute to its successful integration into the teaching process.
3. Encouraging collaborative learning among pupils can further enhance the effectiveness of the lattice method. Group activities, peer tutoring, and collaborative problem-solving can reinforce understanding and promote a positive learning environment.
4. Considering the positive impact of technology, exploring digital tools and educational technologies that complement the lattice method can enhance the learning experience. Interactive applications or software can provide additional practice opportunities for pupils.
5. While the research indicated significant short-term improvements, conducting follow-up studies to assess the long-term effects of the lattice method on pupils' multiplication skills would provide valuable insights into the sustained impact of the intervention.
6. Given the success observed in Basic Six, exploring the applicability and effectiveness of the lattice method in other grade levels could extend the benefits to a broader pupil population.

CONCLUSION

The research has unequivocally established the lattice method as a potent tool for elevating the multiplication skills of Basic Six pupils at Zogbeli Primary School. The substantial improvement observed in pre-and post-test results, supported by a high eta-square value, leaves no doubt about the method's effectiveness. This visual and systematic approach not only enhances comprehension but also cultivates confidence and independent learning. This accommodates diverse learning styles and levels of complexity. The recommendation for integrating the lattice method into the Basic Six curriculum is grounded in the compelling evidence presented, signifying a transformative shift in how multiplication is taught, especially, the traditional long method of multiplication of multi-digit numbers.

The research, while a milestone, is seen as a starting point for future investigations into long-term impact, age group variations, and method comparisons. The positive outcomes underscore the lattice method's potential as a pedagogical tool. This suggests broader implications for effective teaching methods in mathematics. Overall, the findings advocate sustained efforts to refine and promote the lattice method, empowering educators and pupils alike and shaping a generation well-prepared for mathematical challenges and beyond.Confucius' adage, "Tell me and I will forget, show me and I may remember, involve me and I will understand," is now clear in light of these results. If the learning approaches and teaching techniques applied do not fulfil the intellectual needs of the pupils, these could lead to pupils facing difficulties in learning mathematics This also explains why some of the pupils have serious problems with the traditional long method of multiplying multi-digit multiplicands.

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