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On Three New Techniques of Multiplication of Any Two Numbers

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ABSTRACT

A multiplication is one of mathematical operations. It is taught in a school from elementary to high level. Most students consider the operation of multiplication is one of a complex operation. Thus, a lot of techniques are given such as the general stacking technique, the star stacking technique, the line stacking techniques, the Napier-bones technique. Those techniques have been well-known and can be found in the elementary school text book or in the internet such as google or youtube. In this paper, we develop a new technique namely a circle and square stacking technique, and a cross matching technique. Those new techniques show the advantages especially for visual learners style and gain more efficiency in terms of algorithms and number of operations needed.

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INTRODUCTION

Along with this paper, we will discuss three new techniques of multiplication operation. There are four mathematical operations in general, namely addition, subtraction, multiplication and division. The most conventional techniques which have been used since 300 years to solve a multiplication are Napier-Bones technique and stacking technique (Ding, et. al., 2014). The massive extension of the multiplication techniques have been developed such as the star stacking technique, and the line stacking techniques. Those techniques can be found in school text-book and also are available online in https://www.youtube.com/watch?v=eTAevVqQATs. There are many other links through youtube or google, we can also find the techniques in the link https://www.youtube.com/watch?v=_t85yqZSHqY.

We realize that handling the multiplication technique is not quite easy even for just two digits number involvement. Dafik, et. al. (2019) found the elementary school students metacognition skill can not be captured systematically. Some students' thinking skills gain different phase portraits from one student to other students. For the least digit involvement is quite easy to draw but the larger the digit number the more complex their metacognition.

Harini, et. al. (2014) obtained a new technique on multiplication, but they just described a multiplication of a small number, but for a bigger number it will give inefficiently results. Furthermore, Monalisa et al, (2019) found the importance of having fast technique multiplication is needed, especially when solving a paving blocks design problem.

Therefore, in this paper we will give our new results on obtaining a new multiplication technique, namely a circle and square stacking technique, and a cross matching technique. This technique can be considered as more visual technique, and even for the cross matching technique, it is considered to be a more efficient in terms of algorithms and number of operations needed.

METHODOLOGY

This study uses a grounded theory method. Combining research-based activities along with CGANT/CEREBEL research group members, relevant subject-class and combinatorics researchers explore a multiplication technique inductively. Then, we test it deductively under the following steps: *Exposure* stage, *Experience* stage, and *Capstone* stage. Exposure stage is gathering information based on inquiry and looking for literature, or social media focused topics. Experience stage is identifying and formulating problems based on a literature study, social media and experimental experience. Capstone stage is generalising a certain plan or other strategy to solve a problem.

RESULT AND DISCUSSION

From now on, we will describe our research results. We have three new multiplication techniques, namely a circle and square stacking technique, and a cross matching technique. We show the three techniques in the following.

The Circle Stacking Technique

The circle stacking technique is one of a multiplication technique that gains more visual than other techniques. Along with the line stacking technique, the circle stacking technique utilizes the splitting area sign and calculates the splitting area sign to determine the multiplication results. The difference between this technique and the line stacking technique lies in its geometrical shape. In the line stacking technique, we use the lines as geometrically shape while in the circle stacking technique we use the circles as geometrically shape. The circle stacking technique is carried-out by drawing a circle associated with the first number or multiplier (the number in front-side). The number of piles of circles in the first row is the same as the first number of multiplier, then the pile is redrawn or copied as many as the number or digits of the second or multiplied number (the number back-side). Then, proceed to the second, third and so on from the first number or multiplier. The placement of the circle image is arranged vertically down and the number of circles is adjusted by the number at the first number.

Furthermore, by taking into account the second or multiplied number, the stack of circles must be divided vertically by the area (not necessarily the same) whose part is adjusted to the second numbers or multiplied number. If the number 1 appears, then the vertical circle stack must be divided in one area, if the number 2 appears, then the vertical circle stack must be divided by two areas in two areas, if the number 3 appears then the vertical circle stack must be divided in three areas and etc. Mark the divided area by the colored dots, then by the same manner of line stacking technique, count the obtained colored dots diagonally, then it will give the result of multiplication. We should consider the place value of a number. For more systematically being understood, we give the following algorithm.

Algorithm 01.

Given any two number $x_1x_2...x_n$ and $y_1y_2...y_m$
For *i to n*, do
  for *j to m*, do
- Draw a circle associated with the first number or multiplier (The number of piles of circles in the first row is the same as the first number of multiplier)
- Redrawn or copied as many times as the number or digits of the second or multiplied number
- Proceed to the second, third and so on from the first number or multiplier

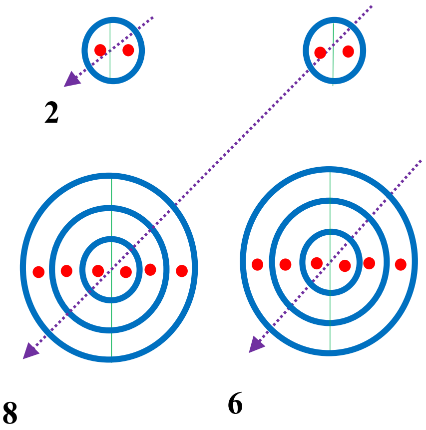
end
  for *j to m*, do
- Devide the stack of circles vertically by the area (not necessarily the same) adjusted to the second numbers or multiplied number.
- Mark the divided area by the colored dots, then by the same manner of line stacking technique,
- Count the obtained the colored dots diagonally

  end
End

For illustration of this technique, we will show the multiplication of any two number as follows:

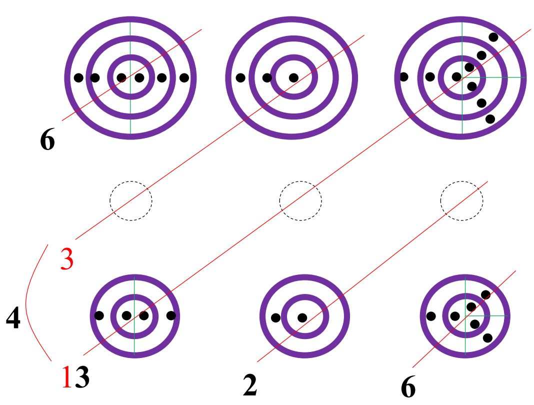
1. *The multiplication of two digit*

   $13 \times 22 = 286$



2. *The multiplication of three digit*

   $32 \times 213 = 64.326$



The Square Stacking Technique

The square stacking technique is exactly the same as the circle stacking technique, it is only differing in geometrically shape. The square stacking technique is done by drawing a square from the first number/multiplier (the first number). The number of square stacks in the first row is the same as the first number of the multiplier. The stacks are drawn again or copied as many numbers/digits in the second number or multiplied (the second number).

Then proceed to the second, third digit and so on of the first number / multiplier. The placement is arranged vertically downward and the number of stacks corresponds to the numbers on the first number. Next, put attention to the second or multiplied number. The square stacks must be divided vertically by area (not necessarily the same) in accordance with the digit of the second number or multiplied. If the number 1 appears then the square stack is vertically divided by one area, if the number 2 appears then the square stack is vertically divided by two areas, when a number 3 appears, then the square is vertically divided by three areas and so on. Mark the divided area by the colored dots, then the same as the circle stacking technique, add up the collection of obtained colored dots diagonally, and it will give a result of multiplication. We need to take into account the place value of a digit of numbers.We write the following algorithm, for more detail.

Algorithm 02.

Given any two number $x_1x_2...x_n$ and $y_1y_2...y_m$
For *i to n*, do
  for *j to m*, do

- Draw a square associated with the first number or multiplier (The number of piles of squares in the first row is the same as the first number of multiplier)
- Redrawn or copied as many times as the number or digits of the second or multiplied number
- Proceed to the second, third and so on from the first number or multiplier

end
  for *j to m*, do

- Devide the stack of squares vertically by the area (not necessarily the same) adjusted to the second numbers or multiplied number.
- Mark the divided area by the colored dots, then by the same manner of circle stacking technique,
- Count the obtained colored dots diagonally

  end

End

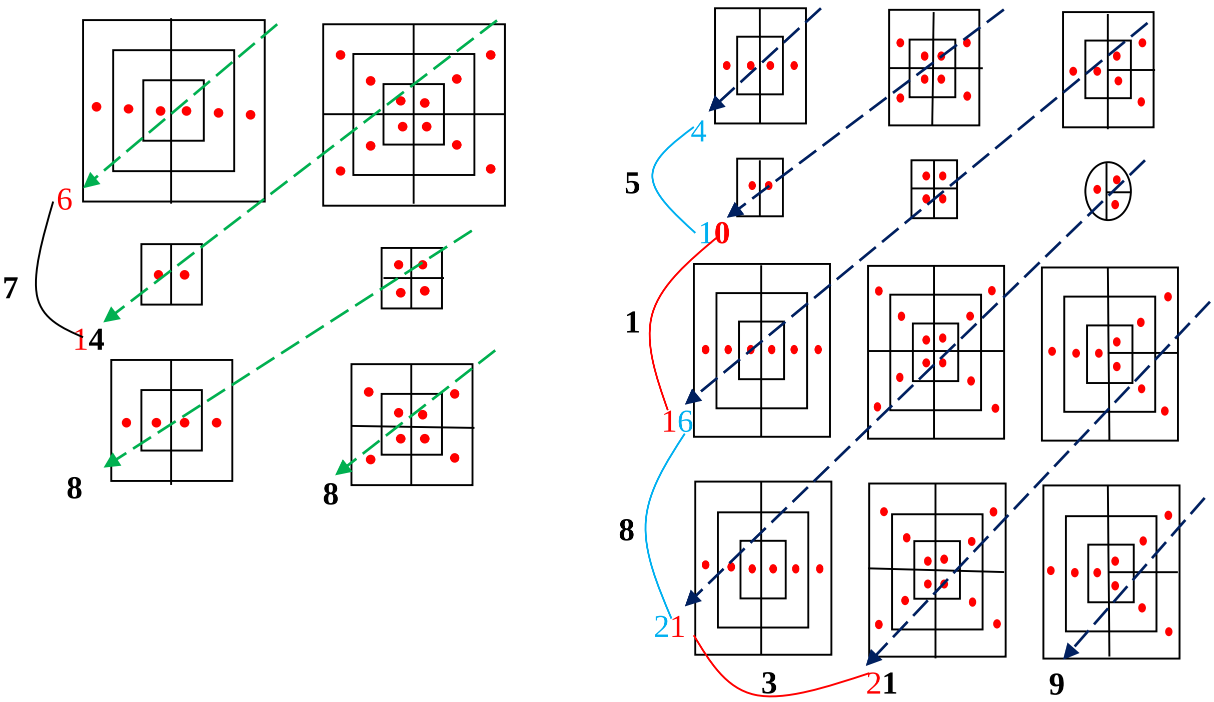
For illustration of this technique, we will show the multiplication of any two number as follows:

1. The multiplication of three digits

   $312 \times 24 = 7488$

2. The multiplication of more than three digits number.

   $2133 \times 123 = 518319$



The Cross Matching Technique

multiplication technique is the most advanced technique for multiplying any two numbers found in this research. We begin by multiplying any two numbers of one digit multiplied by a number of two digits. First, do the multiplication of the numbers by taking attention to the position value of the digits. The first step is to multiply the front-side digit by the front-side digit of each number, including the back-side digit multiplied by the back-side digit. We denote this process by the notation DDBB. Regards the results according to the position value on the digits. Furthermore, do the front-side to back-side and back-side to front-side multiplication, denoted by DBBD. Again, place the results regarding the position values of the digits of the two numbers. Finally read or write the results by starting with the last digits. Consider the place values of these numbers, if it is a unit then write directly as result, if it is tens then we need to add to the available front, keep working on that manner until reaching the desired results. Note, the square brackets notation [..] on the multiplication result is a notation for storing the multiplication, but it is not a multiplication operation sign. We also provide the following algorithm.

Algorithm 03.

Given any two number $x_1x_2 \ldots x_n$ and $y_1y_2 \ldots y_m$
For *i to n*, do

- Do the multiplication of the numbers by taking attention to the position value of the digits
- Multiply the front-side digit by the front-side digit of each number, including the back-side digit multiplied by the back-side digit, denoted by DDBB.
- Regard the results according to the position value on the digits.
- Do the front-side to back-side and back-side to front-side multiplication, denoted by DBBD
- Write the results by starting with the last digits.

- Consider the place values of these numbers, if it is a unit then write directly as result, if it is tens then we need to add to the available front,
- Keep working on that manner until reaching the desired results

End

For illustration of this technique, we will show the multiplication of any two number as follows:

Example 1. (Any two numbers of two digits each)

DDBB

1. $13 \times 34 = 3[13]12 = 442$

1 x 3 = 3

3 x 4 = 12

DBBD

$13 \times 34 = 4 + 9 = 13$

1 x 4 = 4

3 x 3 = 9

DDBB

2. $27 \times 49 = 8[46]63 = 1323$

2 x 4 = 8

7 x 9 = 63

DBBD

$27 \times 49 = 18 + 28 = 46$

2 x 9 = 18

7 x 4 = 28

= Addition

= Subtraction

Example 2. (Any two numbers of three digits each)

DDBB

1. $108 \times 264 = 2[6][20][48]32 = 28512$

DBBD

$10 \times 26 = 6 + 0 = 6$

$18 \times 24 + (0 \times 6) = 4 + 16 + 0 = 20$

$08 \times 64 = 0 + 48 = 48$

DDBB

2. $371 \times 186 = 3[31][75][50]6 = 69006$

DBBD

$37 \times 18 = 24 + 7 = 31$

$31 \times 16 + (7 \times 8) = 18 + 1 + 56 = 75$

$71 \times 86 = 42 + 8 = 50$

Example 3. (Any two numbers of four digits each)

DDBB

1. $2082 \times 1169 = 2[2][20][28][50][84]18 = 2433858$

DBBD

$20 \times 11 = 2 + 0 = 2$

$28 \times 16 + (0 \times 1) = 12 + 8 + 0 = 20$

$22 \times 19 + 08 \times 16 = 18 + 2 + 0 + 8 = 28$

$02 \times 19 + (8 \times 6) = 0 + 2 + 48 = 50$

$82 \times 69 = 72 + 12 = 84$

DDBB

2. $1910 \times 9014 = 9[81][10][13][37][4]0 = 17216740$

DBBD

$19 \times 90 = 2 + 0 = 2$

$11 \times 91 + (9 \times 0) = 1 + 9 + 0 = 10$

$10 \times 94 + 91 \times 01 = 4 + 0 + 9 + 0 = 13$

$90 \times 04 + (1 \times 1) = 36 + 0 + 1 = 37$

$10 \times 14 = 4 + 0 = 4$

Example 4. (Any two numbers of three and two digits)

DDBB

1. $371 \times 86 = 24[74][50]6 = 31906$

DBBD

$37 \times 86 = 18 + 56 = 74$

$71 \times 86 = 42 + 8 = 50$

DDBB

2. $231 \times 12 = 2[7][7]2 = 2772$

DBBD

$23 \times 12 = 4 + 3 = 7$

$31 \times 12 = 6 + 1 = 7$

Example 5. (Any two numbers of four and two digits)

DDBB

1. $4256 \times 72 = 28[22][39][52]12 = 306432$

DBBD

$$42 \times 72 = 8 + 14 = 22$$
$$25 \times 72 = 4 + 35 = 39$$
$$56 \times 72 = 10 + 42 = 52$$

DDBB

2. $6374 \times 56 = 30[51][53][62]24 = 356944$

DBBD

$$63 \times 56 = 36 + 15 = 51$$
$$37 \times 56 = 18 + 35 = 53$$
$$74 \times 56 = 42 + 20 = 62$$

Example 6. (Any two numbers of four and three digits)

DDBB

1. $2345 \times 231 = 4[12][19][25][19]5 = 541695$

DBBD

$$23 \times 23 = 6 + 6 = 12$$
$$24 \times 21 + (3 \times 3) = 2 + 8 + 9 = 19$$
$$35 \times 21 + (4 \times 3) = 3 + 10 + 12 = 25$$
$$45 \times 31 = 4 + 15 = 19$$

DDBB

2. $5382 \times 467 = 20[42][85][77][68]14 = 2513394$

DBBD

$$53 \times 46 = 30 + 12 = 42$$
$$58 \times 47 + (3 \times 6) = 35 + 32 + 18 = 85$$
$$32 \times 47 + (8 \times 6) = 21 + 8 + 48 = 77$$
$$82 \times 67 = 56 + 12 = 68$$

Based on the results of this study, it shows that the multiplication technique with circles and squares stacking techniques provide students with a visual phase. Students are not required to use a complex mathematical operation, such as multiplication, addition, then storing the temporary results and adding them regarding the position values as other techniques, but only, by simply drawing a circle or square, divide them according the area and draw a colored dot as it is mentioned in the algorithm. Thus, by using only additional operations, we gain an accurate result. It is inline with Nazula et. al (2018), the use of visual media, it will be able to encourage the students creative thinking skills.

Furthermore, the cross matching technique obtained in this study also gives some benefits. One of them is the efficiency in the multiplication steps. It implies that this multiplication will take faster than other techniques, a part of it, this technique is easy to remember. Even Though, this technique involves a more complex thinking process, it still provides a higher efficiency in terms of algorithm. This technique is very good for students who have entered the abstract thinking stage and have a good induction and deduction thinking skills.

CONCLUSION

This research has shown three new techniques in multiplication that have never been used before. All three techniques provide excellence and convenience strategy in doing multiplication. However, someone who has a different learning and thinking style will give different perceptions to several techniques, thus each technique can provide advantages or otherwise provide a complexity for the reader. Some new techniques are needed to be continually developed to enrich some choices for readers in multiplication operations. Therefore, we still propose the following open problems:

Open Problem 01. Determine other techniques of multiplication of any two numbers and then show their features and advantages.

Open Problem 02. Determine the multiplication of any two specific numbers then determine their properties

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