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Effectiveness of Japanese Multiplication Method on Improving Grade Two Malaysian Students' Multiplication Computation Fluency

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Abstract

Multiplication is one of the arithmetic operations that is very useful in daily life. However, multiplication computation fluency found to be difficult to master by Malaysian students. To address this problem, this study is conducted to determine the effectiveness of Japanese multiplication method on improving grade two Malaysian students' multiplication computation fluency. Quasi-experimental study is adopted as the research design of this study. A total of 30 students each was selected from two elementary school in Malaysia using multistage cluster sampling. The students in the control group were taught to perform multiplication using column method, whereas the students in the experimental group were taught to perform multiplication using the Japanese approach. The findings indicate that there is significant difference of mean post-MCFT scores between both groups after receiving the intervention and the effect size of the intervention is considered large. In other words, the finding indicates that Japanese Multiplication Approach is more effective approach in multiplication computation. Thus, this study suggests that Japanese multiplication method could be taught in mathematics classroom as the alternative methods to perform multiplication.

Keywords: Arithmetic Operation, Multiplication, Computational Fluency, Japanese Multiplication Method, Elementary School

Introduction

Multiplication is one of the arithmetic operations that is very useful in daily life. According to Isoda and Olfos (2019), multiplication is used to find the total quantity based on the given number of units and unit quantity. For example, the students would apply multiplication to find the total number of apples, given that there are three baskets of apples, and each basket contains five apples. Besides that, multiplication lays the foundation for understanding more advanced concepts (Zhang et al., 2019) such as division, fraction, and ratio. This basic mathematical concept is included in elementary mathematics curriculum.

Multiplication is commonly being introduced in Grade One or Grade Two in most countries (Olfos et al., 2019). As the pre-requisite skills for mastering multiplication computation, the students in most of the country would learn the skip counting of two in Grade One (Olfos et al., 2019). Then, multiplication will be introduced as repetitive addition, followed by introducing the multiplication facts starting from the row of two and five, and gradually extend to the row of three and four, the row of six and eight, and lastly the row of seven and nine (Olfos et al., 2019). In general, the learning of multiplication tables is expected to be completed in the second or third grade (Olfos et al., 2019). Then, the students will be taught to perform computation to determine the products of multidigit number with single digit number, followed by multidigit number with multidigit number (Olfos et al., 2019).

In Malaysian context, the concept of multiplication is being introduced in Grade One as repetitive addition. Then, the students will learn about the basic facts involving multiplication of one-digit number with one-digit number in Grade Two. This was followed by learning to perform multiplication of any numbers with the products up to 10000 in Grade Three. In other words, basic multiplication facts and the multiplication computation fluency serve as the basis for robust understanding in multiplication (Lyold, 2016). However, Mahmud and Rahim (2023), highlighted that the Malaysian students always having difficulties in mastering multiplication computation fluency. These students made conceptual errors as well as procedural errors including the place value errors (Ahad et al., 2018). In fact, some of them do not know how to begin the multiplication process (Ahad et al., 2018). This could be due to unsatisfactory mastery of basic multiplication facts introduced in Grade Two. The lack of basic multiplication computational fluency would eventually obstruct their mastery of more advance topics in future.

Computational fluency is defined as the ability to perform arithmetic operations efficiently and accurately (NCTM, 2020). As such, accuracy and speed commonly being claimed as the two main facets of computational fluency (Gojak, 2012; Zhang et al., 2019). To perform multiplication fast and accurate, the students would have to retrieve the basic multiplication facts. While memorizing multiplication table would support essential retrieval of basic multiplication facts, it becomes the culture in multiplication teaching in Eastern countries (Olfos & Isoda, 2021; Zhang et al., 2019). Likewise, Malaysian students memorize the multiplication table, followed by learning to perform multiplication using the standard algorithm named column multiplication method as shown in Figure 1.

		1	5
x		1	2
		3	0
	1	5	
	1	8	0

Figure 1 Column Multiplication Method

By using the column algorithm, the students would multiply the multiplicand (i.e., 15) with each digit of multiplier (12) in order to obtain the product. The process begins with writing the multiplier (i.e., 12) below the multiplicand (i.e., 15) following the place value of each digit. Then, the students would multiply the unit digit of 12 (i.e., '2') with the multiplicand (i.e., 15) to obtain the partial product, and write down the partial product underneath the multiplier. After that, the students would multiply the tens digit of 12 (i.e., '1') with the multiplicand (i.e., 15) to obtain the second partial product, and write down the second partial product underneath the first partial product. Lastly, the students would add the two partial products to obtain the product of the multiplicand (i.e., 15) and multiplier (i.e., 12).

Recently, Japanese multiplication method had gained the attention of educators in supporting students' mastery of multiplication computation fluency. This approach is also known as stick multiplication (Mayos, 2024), line multiplication (West & Bellevue, 2011), as well as crossline multiplication (Yap & Abdullah, 2019). In this study, Japanese multiplication method is consistently used throughout the manuscript because this approach is introduced by Professor Fujisawa Rikitaro from Japan (Garain & Kumar, 2018). The use of Japanese multiplication method to determine the product of 12 x 15 is as shown in Figure 2.

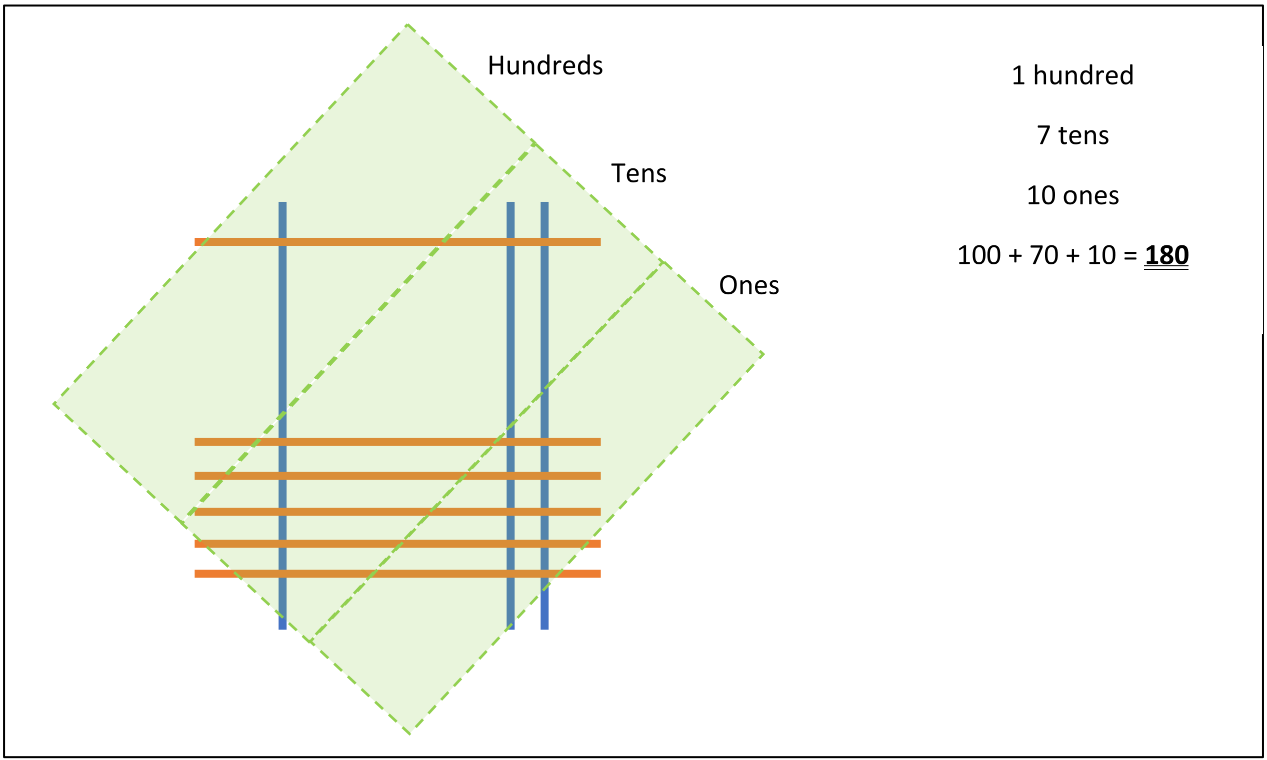

Figure 2 Japanese Multiplication Method

At the beginning, the students would draw one vertical line to represent the tens digit of the 12 (i.e., '1'), and then draw two vertical lines to represent the unit digit of 12 (i.e., '2') after leaving some space. After that, the students would draw one horizontal line intersecting the horizontal lines to represent the tens digit of the 15 (i.e., '1'), and draw five vertical lines intersecting the horizontal lines to represent the unit digit of 15 (i.e., '5') after leaving some space. Then, the students group the intersections as units, tens, and hundreds from the right bottom of diagram drawn and identify the number represented by each place value. Lastly, the students perform addition to determine the products of the multiplication of the two digits.

The effectiveness study of Japanese multiplication method on students' achievement have been conducted by several researchers in the past. Mustafa et al. (2021) conducted pre-experimental study in an elementary school in South Sulawesi, Indonesia. The result of the study indicated that students' ability to perform multiplication has been improved after implementing the intervention. Likewise, the action research conducted by Nur Ulwiyah and Mega Novela Ragelia (2020) as well as Pertiwi et al. (2023) also yield the same result. The 31 elementary Indonesian students' skill in performing has been improved after learning the Japanese multiplication approach. Different with the study conducted by Mustafa et al. (2021) as well as Nur Ulwiyah and Mega Novela Ragelia (2020), Abari and Tyovenda (2022) as well as Aliyu (2022) conducted quasi-experimental studies to compare the effectiveness of Japanese multiplication method and column multiplication method on elementary Nigerian students' ability to perform multiplication. The result of the studies indicated that the students perform better by using Japanese Multiplication method.

Japanese multiplication method was found to be an effective method in performing multiplication. Notably, the past study mainly conducted in Indonesia (Mustafa et al., 2021;

Nur Ulwiyah & Mega Novela Ragelia, 2020; Pertiwi et al., 2023) and Nigeria (Abari & Tyovenda, 2022; Aliyu; 2022). Despite multiplication computation fluency found to be difficult to master by Malaysian students, lack of the study focusing on the effectiveness of Japanese multiplication method. This indicate there is crucial need to determine the effectiveness of Japanese multiplication method on Grade Two students' multiplication computation fluency. Specifically, the research question and the hypothesis of this study are as follows.

Research Question

Is there any significant difference in multiplication computation fluency among the students who use column multiplication method and the students who use Japanese multiplication method?

Null hypothesis

There is no significant difference in multiplication computation fluency among the students who use column multiplication method and the students who use Japanese multiplication method.

Method

Research Design

The research was conducted by adopting the quasi-experimental research design, named non-equivalent control group pre-test and post-test design which could provide substantial control on the validity threats when the participants could not being assign randomly into control and experimental group (Gay et al., 2012). As shown in Table 1, both groups will be pre-tested prior receiving the intervention. Then, both groups will be post-tested after the intervention.

Table 1

Research Design

Group	Pre-test	Treatment	Post-test
Control Group	O_1	X_1	O_2
Experimental Group	O_1	X_2	O_2

Note. O_1 = Pre-test of Multiplication Computation Fluency, O_2 = Post-test of Multiplication Computation Fluency, X_1 = Conventional Multiplication Approach, X_2 = Japanese Multiplication Approach

Research Participants

Population of the study is Grade Two students in National-Type Tamil Primary School (NTTPS) in Bukit Mertajam District, of Penang state, Malaysia. The samples of the study are selected by using multistage cluster sampling. At the first stage of the sampling process, two out of five NTTPSs in Bukit Mertajam District were randomly selected to participate in this study. At the second stage of the sampling process, the students from one intact class of each chosen school were randomly selected as the research participants. The intact class selected were then randomly assigned as control group and experimental group of the study. As shown in Table, each group consisted of 30 participants.

Table 2
Research Design

Group	Number of Participants
Control Group	30
Experimental Group	30
Total	60

Research Instrument

The research instrument of this study is Multiplication Computation Fluency Test (MCFT) that consists of 10 constructed response items about basic multiplication facts. The duration of the test is 30 minutes. The research participants would have to show their work on the test paper. The MCFT is developed as two parallel versions of the test, namely pre-MCFT and post-MCFT. The two sets of tests consist of the same items which are arranged in different sequences. To ensure the content validity of the instrument, the instrument has been validated by experienced mathematics teachers. Then, the instrument was piloted to 30 students. With Cronbach Alpha of .85, the instrument is reliable to measure students' multiplication computation fluency (George & Mallery, 2019).

Research Procedure

The research began with obtaining permission to conduct research from the Educational Planning and Research Division (EPRD), followed by the state education department. With the participated school headmasters' consent, the researcher administered the pre-test to the participants in the control group and the experimental group. Then, the control and intervention groups received eight 30-minute intervention sessions each. During the intervention session, the students in control and intervention groups will learn to perform multiplication using conventional approach and Japanese Multiplication Approach. One week after the intervention sessions, the researcher administered the pre-test to the participants in both groups.

Result

The data of the study was analysed using Statistical Package of Social Science (SPSS) version 27. Before performing hypothesis testing, the normality of the data was assessed. As shown in Table 3, the skewness of all data set falls between the range of -1.50 to 1.50. Thus, the pre-MCFT and post- MCFT scores of the students in control and experimental groups were normally distributed (George & Mallery, 2019). The normality assumption was not violated.

Table 3
Skewness and Kurtosis

Data set	Skewness	Kurtosis
Control Group		
Pre-MCFT	.67	.05
Post-MCFT	-.01	-.54
Experimental Group		
Pre-MCFT	-.13	-.88
Post-MCFT	.76	-.32

The descriptive statistics of pre-MCFT and post- MCFT scores of the students in control and experimental groups were tabulated in Table 4 The students in the control group and experimental group scored 4.00 (*SD* = .87) and 3.97 (*SD* = 1.03) respectively on average in the pre-MCFT. To check the equality of multiplication computation fluency of students in both groups, the independent samples t-test were performed. The result of the test is as shown in Table 5. To check the homogeneity assumption of the group variance, the Levene test has been performed. With p value of .12 (>.05), the variance of two groups could be assumed to be equal. With the mean difference of .03, there is no significant difference of mean pre-MCFT scores between both groups before receiving the intervention, *t (58) = -.14, p = .89*. In other words, the multiplication computation fluency of students in both groups is almost equal before receiving the intervention.

Table 4
Descriptive Statistics

Data set	Mean	Standard Deviation
Control Group		
Pre-MCFT	4.00	0.87
Post-MCFT	4.67	0.84
Experimental Group		
Pre-MCFT	3.97	1.03
Post-MCFT	8.53	0.63

Table 5
Result of Independent Samples T-Test of the Pre-MCFT

Levene's Test for equality of Variances			t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Differences	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Equal variances assumed	2.44	.12	-0.14	58	.893	-0.03	0.25	-0.53	0.46
Equal variances not assumed			-0.14	56.38	.893	-0.03	0.25	-0.53	0.46

As reported in Table 4, the students in the control group and experimental group scored 8.53 (*SD* = .63) and 4.67 (*SD* = .84) respectively on average in the post -MCFT. To test the hypothesis of the study, an independent samples t-test was performed. The result of the test is as shown in Table 6. To check the homogeneity assumption of the group variance, the Levene test has been performed. With p value of .13 (>.05), the variance of two groups could be assumed to be equal. The result independent samples t-test of the post-MCFT indicates that, there is significant difference of mean post-MCFT scores between both groups after receiving the intervention, *t (58) =* -20.12*, p* <.001. Thus, the hypothesis is rejected. With Cohen D of 5.20 (>.80), the effect size of the intervention is large. In short, the finding indicates that Japanese Multiplication Approach is more effective approach in multiplication computation.

Table 6
Result of Independent Samples T-test of the Post-MCFT

Levene's Test for equality of Variances			t-test for Equality of Means						
	F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Differences**	**Std. Error Difference**	**95% Confidence Interval of the Difference Lower**	**Upper**
Equal variances assumed	2.43	.13	-20.12	58	<.001	-3.87	0.19	-4.25	-3.48
Equal variances not assumed			-20.12	53.60	<.001	-3.87	0.19	-4.25	-3.48

Discussion and Conclusion

The study is conducted to determine the effectiveness of Japanese multiplication approach on Grade Two students' multiplication computation fluency. The finding of this study indicates that Japanese Multiplication method is more effective than the column approach to support students' multiplication computation fluency. This finding is in line with the study conducted by Abari and Tyovenda (2022), as well as Aliyu (2022), in which the students performed better in multiplication test by using Japanese multiplication method, compared to the column multiplication method.

The Japanese multiplication method is more effective than column multiplication method because performing multiplication using column method require retrieval of multiplication facts (Katzoff et al., 2020) whereas performing multiplication using Japanese method mainly relying on visualization (Garain & Kumar, 2018). The students determine the products by counting the number of intersections under each place value group and adding the numbers represented by each place value. In other words, memorizing multiplication table is not the prerequisite requirement for performing multiplication using the Japanese method. The students who fail to retrieve multiplication facts can also perform multiplication correctly using the Japanese method.

In short, the findings of this study suggest that that Japanese Multiplication method an effective approach to support students' multiplication computation fluency. Thus, Japanese multiplication method could be taught in mathematics classroom as the alternative methods to perform multiplication. The teachers are encouraged to teach the students who unable to memorize the multiplication facts to perform multiplication using the Japanese method so that their multiplication computation fluency could be improved.

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