

Spaced Learning Strategy in Teaching Mathematics

Ace T. Ceremonia, Remalyn Q. Casem

Abstract—Students' low mastery of the lesson in Mathematics is one of the alarming problems confronted by Mathematics teachers. It is in this light that this study was conceptualized to determine the effectiveness of spaced learning strategy on the performance and mastery of DMMMSU Laboratory High School students (Grade 7) in Mathematics. This study used the true experimental design, specifically the pretest-posttest control group design. The main instrument used to gather data was the pretest-posttest which was subjected to validity and reliability tests. It was found out that the experimental and control groups were comparable in the pretest and posttest. Comparison on their gain scores revealed significant difference with the performance of the experimental higher than the control group. It was also found out that the effect size of using the spaced learning strategy was large. This indicates that the intervention is effective in increasing the performance and mastery of high school students in Mathematics. It is recommended the use of the Spaced Learning Strategy to improve the performance of the high school students in Mathematics.

Index Terms— basic education, effect size, mathematics performance, spaced learning strategy.

1 INTRODUCTION

1.1 Situation Analysis

Quality education is reflected on the exemplary outputs and outstanding performances of students in academics and related co-curricular activities (Glossary Education Reform, 2015). Sui-cho HO (2013) opined that quality education can be viewed in such countries like Japan, Korea, and Finland whose performance ratings in the international examinations and evaluations are definitely high, especially in the field of mathematics, science and reading educations.

In fact, as presented in the report of the Organization for Economic Cooperation and Development (OECD, 2013), Japan ranked 2nd in Mathematics and 1st in both Reading and Science educations during the conduct of the Asia Pacific Educational Assessment and Evaluation in 2012. Meanwhile, International Assessment of Educational Progress (2013) disclosed that Korea holds the highest Mean Percentage Scores in the field of Math and Science. Moreover, Programme for International Student Assessment (2013) revealed that among 41 comprehensive countries being surveyed, Finland ranks 1st in Math, Science and Reading educations. In line with this, Charley and Sui-cho Ho (2013) emphasized on their journals that these countries excelled much due to students' total mastery of the concepts and skills.

In the Philippine context, Calica (2015) emphasized that Mathematics performance of Filipino students in the National Achievement Test (NAT) is seemingly deteriorating and downgrading, if not, stable in the below mastery level. As stated by Capate and Lapinid (2015), the 2015 NAT math result for high school is at a low 46.38%. Moreover, in the international test

results, such as the 2003 TIMSS (Trends in International Mathematics and Science Study), the Philippines ranked 34th out of 38 countries in HS II Math and ranked 43rd out of 46 countries in HS II Science; for grade 4, the Philippines ranked 23rd out of 25 participating countries in both Math and Science. In 2008, even with only the science high schools participating in the Advanced Mathematics category, the Philippines ranked lowest.

As a reflection of mathematics performance of students in the national and international testing and evaluation, the Laboratory High School of Don Mariano Marcos Memorial State University experienced the same situation with regards to NAT results. As reported by the Department of Education (2015), particularly City Schools Division of San Fernando, La Union, DMMMSU MLUC - LHS ratings for four consecutive years are indeed alarming and disturbing: SY 2011-2012 (38.75%); SY 2012 - 2013 (42.79%); SY 2013 - 2014 (42.97%); and SY 2014 - 2015 (39.43%). These reflected mathematics performances in the NAT are considered below mastery level.

Truly, mastery of concepts and skills should be strictly observed by the teacher. Kondektar (2013) opined that one way to master concepts is to repeat it, thus, effective repetition of topics is a good support to mastery learning. Moreover, based on the findings of Thalheimer (2015), effective repetition of topics should be applied in teaching to sustain and improve learning but gaps must be observed. He also cited that spaced repetition is more effective than non-spaced repetition. Supported by Thalima (2015), spacing is particularly beneficial if long-term retention is the goal—as is true of most training situations. Spacing helps minimize forgetting. Wider spacings are generally more effective than narrower spacings.

In relation to student achievement, Klinton (2015) mentioned that performances of students exposed in repetitive teaching attained high scores compared with students exposed in non-repetitive teaching as well as their attitude towards the learning content becomes responsive. Jolass (2015) also stated that students with high retention or long-term memory are able to get high scores in the tests. Moreover, Donovan (2013) meta-analysis

- **Ace Ceremonia** is a holder of Master of Arts in Technology Education – Major in Mathematics. He is currently connected to Don Mariano Marcos Memorial State University, La Union, Philippines. E-mail: ace.ceremonia@yahoo.com
- **Remalyn Q. Casem** is currently pursuing her doctorate degree program in Mathematics. She is an Assistant Professor in Don Mariano Marcos Memorial State University, La Union, Philippines.. E-mail: rhem_vhinz@yahoo.com

suggested that those who learn information by spaced repetition will outperform 67% of those who learn by mass presentation given the same number of practice episodes. Moreover, the attitude of students was also noted that students exposed in spaced learning enjoy more of the learning discussion and are able not to infuse anxiety to the learners.

Due to aforesaid statements, the researchers conceptualized this study to improve the retention or the long-term memory (mastery) of students which will be reflected through the performance of the students in Mathematics.

1.2 Theoretical Framework

There are many theories, principles and scientific evidences which served as bases of the researchers in conceptualizing this study. These theories include theory of spacing effect, Ebbinghaus Forgetting Curve, and testing effect, and principle of science.

First is the *theory of spacing effect*. Thalheimer (2015) said that spacing effect occurs when teachers present learners with a concept to learn, wait some amount of time, and then present the same concept again. Spacing can involve a few repetitions or many repetitions. Spaced repetitions need not be verbatim repetitions. Repetitions of learning points can include the following: (1) Verbatim repetitions; (2) Paraphrased repetitions (changing the wording slightly); (3) Stories, examples, demonstrations, illustrations, metaphors and other ways of providing context and example; (4) Testing, practice, exercises, simulations, case studies, role plays and other forms of retrieval practice; (5) Discussions, debate, argumentation. Repetitions can also be delivered to different perceptual modalities (visual, auditory, olfactory, kinesthetic) and through different learning media. Thus, he said that spacing effect is the finding that spaced repetitions produce more learning—better long-term retention—than repetitions that are not spaced. It is also the finding that longer spacings tend to produce more long-term retention than shorter spacings (up to a point where even longer spacings are sometimes counterproductive).

Ebbinghaus (1885) stated that spacing effect happens when you present and repeat information over intervals of time and it's encoded in ways that cause it to be preferentially retained. He also presented the idea of forgetting curve in which he derived after he memorized a series of nonsense syllables and then tested his memory of them at various periods ranging from 20 minutes to 31 days. This is a simple but landmark research project of him which was the first to demonstrate that there is an exponential loss of memory unless information is reinforced.

On the other hand, Juggar (2014) stated that the spacing effect is still debatable due to following reasons: (1) wider spacings require extra cognitive effort and such effort creates stronger memory traces and better remembering; (2) wider spacings create memory traces that are more varied than narrow spacings, creating multiple retrieval routes that aid remembering; and (3) wider spacings produce more forgetting during learning, prompting learners to use different and more effective encoding strategies that aid remembering in the future.

The second is the *theory of testing effect*. Lambert (2015) said that testing effect happens when the teacher present information in a 'test' format, rather than just reading it, long-term retention is dramatically improved. He also mentioned that testing effect is the finding that long-term memory is increased when some of the

learning period is devoted to retrieving the to-be-remembered information through testing with proper feedback.

The effect is also sometimes referred to as retrieval practice, practice testing, or test-enhanced learning. As opined by Topino T.C. and Cohen M.S. (2012), the testing effect occurs when adding tests to one's learning regimen benefits retention more than including a comparable amount of additional studying, particularly when the initial testing involves recall. This phenomenon has considerable potential for improving educational effectiveness. It is useful for people to test their knowledge of the to-be-remembered material during the studying process, instead of solely studying or reading the material. The testing effect provides the largest benefit to long-term memory when the tested material is difficult enough to require effort, the retrieval success is high, and feedback with correct answers is given after testing.

The third, is the *principle of science*. Monkseaton High School (2015) stated that repeated stimulation of the same neural pathway demonstrates its importance to the brain and makes it easier to locate when you need to access the information stored within it. Spaced Learning is a way of creating neural pathways at the start of a unit of work (memory acquisition), which can then be revisited at various intervals over time (memory retrieval). This will emphasize the pathway's importance and make it easier for you to 'locate' it when you need it.

Spaced Learning is based on a discovery about the brain that was published in 2005 by R. Douglas Fields in Scientific American. Fields, of the National Institute for Child Health and Development in the US, led the team investigating the science behind how the brain actually creates a memory. The team's research uncovered the process by which long-term memories are formed, and (more significantly for teachers) the process by which they can be created. The biological basis of a memory is a pathway of cells linked together within the brain. Fields' team focused on how each cell was 'switched on' and became linked to other cells. Their experiments demonstrated that it is the manner in which the brain's cells are stimulated that causes them to 'switch on' and link together. Surprisingly, constant stimulation of the cell did not make the cells switch on. Stimulation had to be separated by gaps when the cell was not stimulated. The breakthrough came when the team 'began to realize that the important factor was time'. The length of stimulation was not vital, but the gap between stimulations was. Moreover, this spaced learning strategy will also enhance students' attitude and able to create a stimulating atmosphere during class discussions.

After discussing the above mentioned theories, these theories served as guides of the researchers in conducting the study particularly on preparing the instrument as well as in the conduct of the intervention. Thus, this study affirmed the use of the Input-Process-Output (IPO) Model and further aimed to determine the effectiveness of Spaced Learning Strategy in Teaching Mathematics among Grade 7 students of DMMMSU MLUC - Laboratory High School for the school year 2016 - 2017. Specifically, it sought to answer the following questions:

1. What are the performance ratings of the two groups of research participants in terms of:
 - 1.1) pre-test; and
 - 1.2) post-test?

2. Is there a significant difference between the performance ratings of the two groups of research participants in terms of:
 - 2.1) pre-test; and
 - 2.2) post-test?

2 METHODOLOGY

2.1 Research Design

True experimental research design was employed in this study, particularly the pretest-posttest control group research design to obtain adequate control of sources of invalidity. As stated by Hanes (2016) true experimental design is regarded as the most accurate form of experimental research, in that it tries to prove or disprove a hypothesis mathematically, with statistical analysis. Moreover, Heffner (2016) opined that true experimental design makes up for the shortcomings of the two designs previously discussed. They employ both a control group and a means to measure the change that occurs in both groups. In this sense, we attempt to control for all confounding variables, or at least consider their impact, while attempting to determine if the treatment is what truly caused the change. With these premises, the researchers considered true experimental research design as the best design for the study.

2.2 Procedure

**TABLE 1.
RESULT OF THE EQUIVALENCY TEST
FOR THE TWO GROUPS OF PARTICIPANTS**

	Mean	Variance	t-test p-value
Control Group	85.27	8.92	0.08
Experimental Group	86.07	13.21	

*Significant at $\alpha = .05$

Thirty (30) Grade 7 students of DMMMSU-MLUC Laboratory High School were considered as participants of the study. There were fifteen (15) randomly selected participants for each of the two groups: Control and experimental. To ensure equivalency of the two groups, IQ results during their Laboratory High School Admission Test (LHSAT) was considered to come up with possible pairings. Furthermore, the final Mathematics grades of the participants during their 6th Grade were considered to check differences on the means. T-test p-value equal to 0.08 compared to 0.05 level of significance further revealed that there is no significant difference between the two groups of participants. Table 1 shows the result of the equivalency test.

Participants in the control group were taught using traditional instruction which made use of the lecture method, board works, drills and worksheets singly or in combination. On the other hand, participants in the experimental group were exposed to spaced learning strategy in which the teaching-learning process was divided into three major inputs: 1) presentation; 2) recall; and 3) retrieval/application.

The researchers made their every effort to teach the two groups of participants to the best of their ability so as not to sway the findings of this study.

The main instrument used in this study was the pretest-posttest on the identified least mastered topics in Mathematics 7. The pretest-posttest made by the researcher was used to gather data in order to determine the mathematics performance of the two groups of participants before and after the study.

The draft of the pretest-posttest which originally of 100 items was reproduced and subjected for pilot testing by the researcher to randomly selected 45 Grade 7 students of DMMMSU North La Union Campus, Sapolang, Bacnotan, La Union.

To secure consistency of the 100-item pretest-posttest, the Kuder-Richardson Formula 20 was used. The computed reliability coefficient of 0.84 indicates that the test was reliable. Moreover, it satisfied the reliability coefficient requirement for a classroom exam which is at least 0.70 (Wells & Wollack 2003).

Though the test was "highly reliable", twenty-three (23) items were discarded due to very low (too easy) and very high (too difficult) indices. Point biserial values of the items were computed to determine which ones were likely to be unreliable. A recommended point biserial value is at least 0.15 and items with point biserial values lower than 0.15 may need further examination or may be deleted (Varma n.d.). This is the basis on the deletion of other twenty-seven (27) items on the original pretest-posttest. The 100-item pretest-posttest was trimmed down to only 50 items.

The final pretest-posttest was comprised of 50 items. The coefficient of reliability of this test instrument was also computed. The final test was reliable with a reliability coefficient of 0.85 which was an improvement from the original test.

Moreover, the researchers also checked on the content validity of the final pretest-posttest by means of the extended assistance of the five subject matter experts who evaluated the instrument. The overall median of the evaluators' assessment is 4 which clearly revealed that the 50-item pretest-posttest was valid.

Data gathered were analyzed statistically by the researchers. Mathematics performance rating was used to determine the level of Mathematics performance of the two groups of participants in the pretest-posttest. The paired t-test was employed to find out if significant difference existed on the level of performance of the two groups of participants before and after the conduct of the study. Mean gain scores and Cohen's d were used to determine the effect size of the use of Spaced Learning Strategy on the mathematics performance and mastery of the participants of the study.

SPSS and Microsoft Excel were used to facilitate the statistical computation of the data

3 RESULTS AND DISCUSSION

3.1 Mathematics Performance of Two Groups of Participants in Terms of Pretest and Posttest

Table 2 on the next page shows the mathematics performance of the control group and the experimental group. It is evident that during the pretest, the mathematics performances of the two groups of participants were low. This could be expected for the groups did not have any little knowledge or background on the different competencies of the topics. It can be further noted that the scores of each participants in their pretest are closed to each other. Meanwhile, for their posttest, it is apparent that there were

changes on the mathematics performance of the participants as compared to their pretest.

TABLE 2.
MATHEMATICS PERFORMANCE RATINGS OF THE TWO GROUPS OF PARTICIPANTS

	Control Learning Group		Spaced Learning Strategy Group	
	(Pretest)	(Posttest)	(Pretest)	(Posttest)
L ₁	23	29	24	37
L ₂	27	34	25	43
L ₃	28	35	27	40
L ₄	29	36	28	45
L ₅	30	46	21	46
L ₆	16	25	20	42
L ₇	20	29	29	43
L ₈	26	29	17	43
L ₉	33	48	18	46
L ₁₀	19	33	24	47
L ₁₁	20	33	27	41
L ₁₂	22	28	19	47
L ₁₃	25	30	20	43
L ₁₄	28	33	18	47
L ₁₅	27	35	34	48

Legend: L_n – learners' number (reference number)

3.2 Comparative Analysis on the Mathematics Performance Ratings of the Two Groups of Participants in their Pretest

Pretest was administered to both groups of participants. Table 3 shows the pretest mean scores of the experimental and control groups, 23.40 and 24.87, respectively. This result indicates that the level of pretest performance of the two groups of participants were both fair. This is due to the fact that about 85 percent of the participants in each group got scores that are below 24, which means that almost all of the participants in each group got unsatisfactory ratings. This result is expected for the topics incorporated in the pretest are not yet discussed in their current curriculum level.

The control group had a higher pretest mean score as compared to the experimental group. Control group also shown that they are more consistent than the participants in the experimental group. Despite of the said comparison, it can be

TABLE 3.
TEST OF SIGNIFICANT DIFFERENCE - PRETEST

	Mean	Variance	t-test p-value
Control Group	24.87	22.27	0.44
Experimental Group	23.40	24.40	

*Significant at $\alpha = .05$

noted that there is no significant difference between the mathematics performances the two groups. This was revealed by the computed t-test p-value of 0.44 which is higher than the

critical value of 2.14. Hence, this only means that the experimental group is comparable to the control group in terms of any possible characteristics. This also implies that the control variables which were considered prior the conduct of the study was used properly as well as effectively mapped telling that the random distribution of the participants in the two groups were of equal chance.

3.3 Comparative Analysis on the Mathematics Performance Ratings of the Two Groups of Participants in their Posttest and Gained Scores

The researcher immediately administered the posttest to both groups right after securing that all topics and competencies were known, introduced and learned by the participants. Thus, it can be gleaned from Table 4 that there is a big difference on the mean scores (10.34) of the two groups of participants. This only means that the experimental has a "very satisfactory" performance than that of the control group whose performance is satisfactory. Though, there are some performance ratings in the control group which are extremely high, there are still some who failed to meet the desired expectation.

Moreover, it also shows that the experimental group is now more consistent (9.55) in their mathematics performance ratings as compared to the control group (39.55). Furthermore, to check whether their posttest mean difference is large enough to support the rejection of the null hypothesis, t-test was performed. It was revealed that their posttest performance differ significantly as shown by the computed t-value of -6.769 which falls on the rejection region. This result signifies that there is a significant difference in the posttest performance of the experimental and control groups. This implies that participants in the experimental performed better than the participants in the control group.

TABLE 4.
TEST OF SIGNIFICANT DIFFERENCE - POSTTEST

	Mean	Variance	t-test p-value
Control Group	33.53	39.55	0.000*
Experimental Group	43.87	9.55	

*Significant at $\alpha = .05$

Meanwhile, the considerable increase on the marks of the participants in the posttest as compared from that in the pretest can be primarily explained by the fact that the topics were already taught to them. But to have a deeper comparison between the two groups, the point of interest, therefore, is on how much or great they improved. To do that, the researchers measured the amount of growth in each group (gain score) and found out that from pretest to posttest, the experimental group averaged 52.65% more growth than the control group.

Table 5 on the next page shows that the experimental group had a mean gain score of 15.95 while the control group was 8.67. A t-test p-value of 0.000 implies that the gain scores of the two groups differ significantly. Since there is a significant difference on the gain scores of the two groups of participants being compared, the effect size was further computed through Cohen's d and able to obtain an effect size value of 0.76 which means that

there is a large effect in the performance of students.

TABLE 5.
COMPARISON ON THE
GAIN SCORES OF THE TWO GROUPS

	Mean	Variance	t-test p-value	d	r
Control Group	8.67	15.95			
Experimental Group	15.95	36.27	0.000*	2.31	0.76

*Significant at $\alpha = .05$

In this regard, the participants in the experimental who are exposed in the intervention named Spaced Learning Strategy got high scores in the test; hence, it redounds to that the intervention is effective in improving the mastery and performance of students in Mathematics.

4 SUMMARY, CONCLUSION, AND RECOMMENDATION

4.1 Summary

1. The mathematics performance of the two groups of participants during the pretest was *low* but their scores during the posttest were apparently got *high*.
2. There is no significant difference on the pretest scores of the two groups of participants; however, significant difference existed on the posttest scores/ratings.
3. The effect size of the spaced learning strategy was large.

4.2 Conclusion

1. This only proves that the two groups of participants obtained higher ratings during posttest than pretest due to the fact that the set of topics incorporated to the test were taught to the best way possible.
2. It only shows that the pairings or groupings of participants able to the homogeneity of the two groups being compared. Moreover, it implies that the participants exposed to spaced learning strategy performed better than the participants who were exposed to traditional mode of teaching.
3. Spaced learning strategy shows that there is a positive effect in improving the mastery and performance of students in mathematics.

4.3 Recommendation

1. The teacher/facilitator should make some interventions in teaching the various lessons in order for students to reach their goal.
2. The use of spaced learning strategy should be adopted by teachers who experienced same situation regarding the poor mastery/ performance of the learners towards certain topic or discussions. This helps students to recall things and perform well in the academics.
3. Since it has been proven that spaced learning improves the mathematical performance of students and has a large effect, it is further recommended to also apply space learning with other

disciplines.

ACKNOWLEDGMENT

The researchers would like to extend their sincerest thanks to the individuals/institutions who/that made this study possible. The researchers love you so much!

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