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THE IMPACT OF TIMED PRACTICE DRILL IN INCREASING THE AUTOMATICITY ON THE FOUR MATHEMATICS OPERATIONS OF GRADE EIGHT STUDENTS IN ZAMBALES NATIONAL HIGH SCHOOL IN THE SCHOOLS DIVISION OF ZAMBALES, PHILIPPINES

Author's Name: [1]Mr. Paul Q. Lesaca, [2]Ms. Teresita A. Falle

Affiliation: [1]*Zambales National High School, Iba, Zambales, Philippines*

[2]*President Ramon Magsaysay State University, Iba, Zambales, Philippines*

E-Mail: paulquiocholesaca@gmail.com

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Abstract

This study aimed to determine the impact of timed practice drill in increasing the automaticity of the four basic mathematical operation facts of selected grade 8 students in Zambales National High School during SY 2018-2019.

The study utilized experimental research design using pre-test and post-test assessment to determine the effectiveness of the time practice drill. The treatment group composed of thirty-five students while the control group with thirty-four students.

The study revealed that for the treatment group, the students were assessed in the pre-test assessment "Did Not Meet Expectation" in the areas of subtraction, multiplication and division while "Fairly Satisfactory" in addition. In the post-test assessment the student was "Outstanding" in addition, subtraction, multiplication and division. For the control group, the student was assessed in the pre-test assessment "Did Not Meet Expectation" in the areas of addition, subtraction, multiplication and division. For the post-test assessment, the students were assessed "did not meet the expectation" in subtraction, multiplication and division respectively while "Fairly Satisfactory" in addition. There is significant difference on the level of performance between pre-test and post-test assessment for the treatment group while not significant in the control group. There is significant difference on the post-test assessment between the treatment and control group while not significant on the pre-test assessment.

Based on the summary and the conclusions arrived at, the study strongly recommends the use of Timed Practice Drill intervention in teaching mathematics across all year and grade level for better academic achievement.

***Keywords**: Automaticity; basic mathematics facts; math fact fluency; intervention; timed practice drill.*

INTRODUCTION

Mathematics skills are essential for every student to learn. They are fundamental to the success of the students through their education and into their professional careers. As students enter the junior high school mathematics classroom, many factors contribute to their potential for success. One essential factor is the students' competence to recall basic mathematics facts with nominal effort and a great deal of accuracy. This type of seemingly unconscious recall is often referred to as *automaticity.* It is the ability to deliver a correct answer immediately from memory without conscious thought, as opposed to relying on calculation (Stickney, Sharp, and Kenyon, 2012). Quite a few mathematics educators and researchers believe that automaticity is absolutely essential in developing estimation and mental computation skills. It is the essence of overall number sense.

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Learning basic math facts fluently and automatically is essential for students to develop automat

Learning basic math facts fluently and automatically is essential for students to develop automaticity in Mathematics in order to master more complex concepts in the future (Parkhurst, Skinner, Yaw, Poncy, Adcock, and Luna, 2010; Geary, 2011; Nelson, Parker, and Zaslofsky, 2016). Automaticity of basic math facts greatly enhances students' chance to be successful with more complex math problems. If students are consistent with their accuracy and speed of computation, they are able to devote more attention to the overall purpose of the problem instead of devoting problem-solving time to basic calculations. An individual, young or old, who cannot automatically recall basic mathematics must expend additional cognitive resources to the mental calculation of basic math facts before moving on to other aspects of a math problem, thus increasing the cognitive load or demand. In contrast, automatic recall of basic math facts reduces cognitive load by eliminating extra calculations and focusing cognitive resources toward solving the more complex aspects of math problems (Parkhurst, et al., 2010).
The application of those basic math facts in other math problems is one of the most fundamental tasks in all math classrooms (Nelson, Burns, Kanive, and Ysseldyke, 2013). The lack of those foundational facts inhibits students in other math areas such as ratios, fractions, division, algebraic factoring, and trigonometry (Flowers and Rubenstein, 2010). This importance of automaticity in math skills for students makes the application in a classroom absolutely necessary to better develop proficient math students.

Considering the importance of mastering math facts for advancing mathematical thinking, two of the identified effective practices for building math automaticity are: by providing ample drill and practice with high rates of response; and include immediate and corrective feedback (Hawkins, Collins, Hernan, and Flowers, 2017; Riccomini, Stoker, and Morano, 2017). To provide enough drill and practice for students to master math facts, teachers need to ensure that students have adequate time to engage with those activities with opportunities to respond. They should be given opportunities as well to practice with immediate feedback to prevent them from practicing incorrect responses. Mastery develops and strengthens as students practice responding correctly to math fact prompts. Without immediate feedback, if students answer math fact items incorrectly, they may assume that their incorrect responses are correct and then risk becoming fluent with wrong answers (Hawkins, Collins, Hernan, and Flowers, 2017). Teachers must ensure that all students receive immediate corrective feedback when practicing math facts. Feedback given after students have completed a practice session (e.g., after students complete an entire worksheet) is not likely to be as effective.

Students graduating from elementary are expected to be fluent in the four basic mathematical operations. Because of this requirement, not a lot of instructional time in high school is devoted to the learning of math facts, since students technically should have those mastered. The truth for this researcher is that most students come into junior high school every year with a lack of automaticity with the basic math facts. This lack of automaticity causes struggles for many students in the junior high school curriculum because almost all concepts require a knowledge of those basic facts. The following study is based on the researcher's experience teaching grade 8 mathematics and will examine the impact of timed practice drill in developing automaticity of basic math facts.

STATEMENT OF THE PROBLEM

This study aimed to determine the impact of timed practice drill in increasing the automaticity of the four basic mathematical operation facts of selected grade eight students in Zambales National High School.

The use of two groups guided this study to specifically answer the following questions:

1. What is the level of performance of Grade 8 students in the treatment group in the pre-test and post-test assessment along the four operation of Mathematics as to:
   1.1 Addition;
   1.2 Subtraction;
   1.3 Multiplication; and
   1.4 Division?
2. What is the level of performance of Grade 8 students in the control group in the pre-test and post-test along the four operations of Mathematics as to:
   2.1 Addition;
   2.2 Subtraction;
   2.3 Multiplication; and
   2.4 Division?
3. Is there a significant difference on the level of performance of Grade 8 students in the treatment and control group along the four operations in Mathematics between pre-test and post-test assessment?
4. Is there a significant difference on the level of performance of Grade 8 students between treatment and control group along the four operations in Mathematics in the pre-test and post-test assessment?

THEORETICAL FRAMEWORK

In order to help students develop and sustain automaticity of basic math facts, an understanding of the origins and development of the cognitive learning, cognitive load, and instructional hierarchy theories would be instrumental. These are the theories where this study finds its theoretical framework. How these theories help address limitations and potential interventions for students who struggle with math achievement in general and the automaticity of math facts specifically would shed light on some of the reasons for the persistent math achievement gap and ways to help close this gap for at-risk student.

Cognitive Learning Theory, also known as the information processing theory, purports that people have a limited amount of cognitive capacity, or the amount of information that can be processed at one time, and this limitation makes it difficult to complete complex tasks (Pegg and Graham, 2007). Working memory on the other hand is generally defined as the ability to hold information within the brain while manipulating other information or as a mental workspace involved in controlling, regulating, and maintaining information needed to accomplish complex cognitive assignments (Tronsky and Royer, 2003). Combined with limited working memory, if a student has deficits with retrieval skills or a slower than adequate processing speed, their working memory reaches capacity (Pegg and Graham, 2007). Unfortunately, since all students need mastery of basic math facts and computational strategies in order to successfully solve problems and perform mental estimations and computations, the information processing theory emphasizes that these basic facts need to be automatic (Baroody, Bajwa, and Eiland, 2009).

Cognitive Load Theory supports the belief that automaticity in math facts is fundamental to success in many areas of mathematics, and that without the ability to retrieve facts directly or automatically, students are likely to experience a high cognitive load as they perform a range of complex tasks. Menon (2010) mentioned that working memory plays a central role in learning mathematics particularly during childhood and adolescence when neurodevelopmental changes are prominent. As children are introduced to more complex mathematics operations, a sound working memory is needed so that information can be held while other higher order tasks are performed. When children routinely memorize math facts through repetition, semantic memory becomes active; therefore, strategies and interventions that include repeated performance aimed at improving automaticity may help lessen processing load and free up working memory that can be dedicated towards more complex cognitive tasks (Menon, 2010).

The **Instructional Hierarchy Theory** proposes that student learn skills via four stages that begin with acquisition, move through a fluency development stage, progress to a stage that includes generalization, and culminates with the ability to apply the learned skill. As it applies to the automaticity of math facts, during the acquisition stage, students would learn a series of math facts with the focus of obtaining correct answer regardless of the length of time required. The second stage utilizes repeated drill and practice to reach proficiency with the learned facts so that they can be automatically recalled with minimal effort. Improving fluency frees up some of the cognitive resources available in short-term memory and allows students greater access to perform more difficult problems when basic math fact accuracy is the foundational piece needed for this complex task. The third stage includes opportunities for the students to generalize math facts to alternate scenarios yet retain automaticity. The goal of this stage is to practice the skill with regularity so that discrimination can be made between this learned skill and others that may be different yet related. The final stage of the hierarchy theory allows the students the chance to apply the facts that they have learned to novel math tasks that rely on fluency for successful completion. The stages are traversed in succession with progression to a subsequent stage dependent on mastery of the previous stage. As it applies to math instruction generally and automaticity specifically, this model indicates that a student who masters basic math facts is more likely and better equipped to approach more complex mathematical operations as they occur (Sarrell, 2014).

RESEARCH METHODOLOGY

Research Design

The researcher employed a quasi-experimental design for this quantitative study, specifically the nonequivalent group pretest posttest design. According to Creswell (2003), a quantitative approach is best if the problem to be researched is to identify factors that have the potential to influence outcome, whether positively or negatively (Knowles, 2010).

Respondents and Sampling Technique

The participants involved in this study were students of the two regular education section in Grade Eight: 8-Guava and 8-Pineapple. Both sections were under the mathematics classes of the researcher. 8-Guava was taught mathematics in the morning and 8-Pineapple had their math class in the afternoon. There were thirty-five (35) participating students in 8-Guava, twenty-one (21) boys and fourteen (14) girls while 8-Pineapple comprised thirty-four (34) students, eighteen (18) boys and sixteen (16) girls. Table 1 shows the frequency and percentage distribution of the respondents.

Table 1. Frequency and Percentage Distribution of the Respondents

Grade and Section	Frequency	Percentage
8 - Guava	35	50.72
8 - Pineapple	34	49.28
Total	**69**	**100.00**

This study took place in a traditional education setting which involves classes that are already intact before the study commenced. It was not feasible for the researcher to incorporate the use of random assignment.

There were no recording of names or other personal identifiers in the conduct of this study. With this anonymity and the fact that the treatment that were used are considered part of the standard curriculum, there was no need to ask for participants' parental consent.

Location of the Study

This study was conducted in Zambales National High School, a secondary school in the Schools Division of Zambales, located at Zone 6, Iba, Zambales, Philippines where the researcher is currently teaching.

Instruments

On the first day of the study, the participants from both the treatment group and control group were administered with a pretest that includes 100 basic math fact problems.

Following the pretest was the administration of timed practice drill using Addition, Subtraction, Multiplication, and Division Flash Cards in the treatment group. These 40-pieces back-to-back Math flash cards contain 10-pieces with addition fact problem on one side and another on the reverse side, 10-pieces with subtraction fact problems, 10-pieces with multiplication fact problems, and 10-pieces with division fact problems. Thus, this treatment group answered 80 Mathematics fact problems in every practice drill.

The students were provided with blank answer sheets and were given exactly two (2) seconds to correctly answer each Mathematics fact problems that was shown by the teacher. Each of the timed math problems answered was immediately followed by instant feedback which provided students with the correct answer, allowing them to monitor their own progress.

This timed practice drill using Mathematics flash cards were administered daily to 8-Guava, the morning class which was referred to as the Experiment Group, for a duration of 25 school days (five weeks). The 8-Pineapple on the other hand was referred to as the Control Group. The afternoon class was not administered any practice drill.

On the 25th day of this study, both the experiment group and control group were administered with a written posttest that also includes 100 basic Math fact problems. The name line at the top of the pretest and posttest were replaced instead with another one pertaining to the students' number that were assigned by the teacher-researcher.

The set of Mathematics Flash Cards that were used as timed practice drill for this study was produced by the researcher using a 21-centimeter long by 14.8-centimeter wide 200 gsm ivory-colored blank card encoded with math fact problems and was adopted, reproduced, and used by

other Zambales National High School Math Teachers in their Grade 7 class numeracy test.
The pretest and posttest administered as part of this study's data gathering was also under the authorship of the researcher. This set of basic Math problems was also adopted and used by the Grade 7 teachers as summative test in their Grade 7 class to test their students' acquired knowledge on the operations of integers.

Data Collection

The researcher sought permission from the principal for the conduct of this study as well as from the Schools Division Superintendent. Upon the approval of the request, the data collection began. Pretest, treatment drills, and the posttest were administered and collected. All pretests and posttests were hand-scored by the teacher-researcher. The total number of correct answers for each test (pretest and posttest) served as the participants' scores. The researcher gathered the results for the interpretation of data.

Data Analysis

The Statistical Package for Social Sciences (SPSS) computer software and MS Excel were used for the computations and interpretations of data. The statistical tools in the analysis and interpretation of data and hypotheses testing include the following:

1. **Mean.** It is also called arithmetic mean and represented by $\bar{x}$ (or x-bar). This is computed by adding all the values of the variable x (the sum of the x values is symbolized by $\sum x$ or summation of x), and dividing the sum by the total number of samples, represented by n. This was used to determine the average of the pretest and posttest results. The formula for this is expressed as $\bar{x} = \frac{\sum x}{n}$.
2. **Weighted Mean.** It is an average in which each quantity to be averaged is assigned a weight, and these weightings determine the relative importance of each quantity on the average. Weightings are the equivalent of having that many like items with the same value involved in the average.
3. **Qualitative Description.** It was used as guide in determining the qualitative interpretation of both the treatment and control groups' level of performance in each of the four Mathematics operations in the pretest and posttest assessment. The computed weighted mean and the corresponding qualitative description are as follows:

Weighted Mean	Qualitative Description
21 - 25	Outstanding
19 - 20	Very Satisfactory
17 - 18	Satisfactory
15 - 16	Fairly Satisfactory
1 – 14	Did Not Meet Expectation

4. **t-test.** This statistical tool was used to determine the following: difference between pretest and posttest along the four areas of Mathematics for the treatment group and control group; to determine difference on the pretest assessment between the treatment and control group; and to determine the difference on the posttest assessment between the treatment and control group.

Decision Rule:

a. If the computed t-value is less than the critical t-value at 0.05 alpha level, the null hypothesis is accepted. There is no significant difference.
b. If the computed t-value is greater than the critical t-value at 0.05 alpha level, the null hypothesis is rejected. There is a significant difference.

RESULTS AND DISCUSSION

Test of Differences on Pre-Test and Post-Test along the four areas of Mathematics

Table 2 shows the t-test to determine difference between the Pre-Test and post-test along the four areas of Mathematics for the Treatment Group.

Table 2. t-test to determine difference between Pre-Test and Post-Test along the four areas of Mathematics for the Treatment Group

Treatment Group	*Pre-test*	*Post-test*
Mean	11.3925	22.5925
Variance	8.793958333	0.695558333
Observations	4	4
Hypothesized Mean Difference	0	
Df	3	
t Stat	-9.44243134	
t Critical one-tail	2.353363435	
t Critical two-tail	3.182446305	

There is significant difference on the level of performance of the students in the four areas of Mathematics between pre-test and post-test assessment for the treatment group manifested on the computed t- value of -9.44243134 which is greater than (>) t-critical value one-tail value of 2.353363435 and t-critical two-tail value of 3.182446305, therefore the Null Hypothesis is Rejected.

The data clearly reveals on the dissimilarity of the treatment group capability and competence between the pre-test and post-test assessment.

The increase of score gains in the post-test assessment for the treatment group could be ascribed on the use of time drill intervention. The provision of Explicit Timing (ET) has been a successful intensive strategy that has been used for increasing fluency and improving student's responses. Explicit timing has seen extensive use due to the ease at which it can be implemented (Duhon, Hastings, House, Poncy, and Solomon, 2015). These techniques can be implemented with large groups of students simultaneously and can be easily implemented in a classroom setting. Interventions have been implemented based off of explicit timing in order to decrease the students automated response time. In 2014, Duhon and Ponce reviewed extensively the effects of explicit timing and how the interventionist provides the learner with a set of problems, and times the learner as they complete as many problems as they can in the time frame. Regardless of what strategy was used, it was concluded that in order to enhance the effectiveness of the interventions, the frequency or duration can be increased. By increasing the frequency, strategy allows the teacher to focus on specific skills for the students to concentrate on. Instead of quickly covering a wide range of skills, they can narrow it down on specific weaknesses and increase the rigor of the practice.

Table 3 shows the t-test to determine difference between the Pre-Test and post-test along the four areas of Mathematics for the Control Group.

Table 3. t-test to determine difference on the Pre-Test and Post-Test along the four areas of Mathematics for the Control Group

Control Group	*Pre-test*	*Post-test*
Mean	11.245	12.39
Variance	6.4745	11.04706667
Observations	4	4
Hypothesized Mean Difference	0	
Df	3	
t Stat	-1.78857132	
t Critical one-tail	2.353363435	
t Critical two-tail	3.182446305	

There is no significant difference on the performance of the students in the four areas of Mathematics between pre-test and post-test assessment for the control group manifested on the computed t- value of -1.78857132 which is less than (<) t-critical value one-tail value of 2.353363435 and t-critical two-tail value of 3.182446305, therefore the Null Hypothesis is Accepted.

The data clearly demonstrate on the parallelism of performance of the control group in the pre-test assessment. All of them similarly encounters problems in the four areas of Mathematics: addition, subtraction, multiplication and division.

In the absence of intensive instruction and intervention, students with mathematics difficulties and disabilities lag significantly behind their peers (Jitendra, Rodriguez, Kanive, Huang, Church, Conrroy, and Zaslofsky, 2013; Sayeski and Paulsen, 2010). Special education teachers and general education teachers need to have strategies to help students who struggle with mathematics to gain access to the general education curriculum and to meet with success in all areas of math including math literacy and conceptual knowledge (Gargiulo and Metcalf, 2013; Powell, Fuchs, and Fuchs, 2013).

Test of differences on the level of performance between treatment and control Group

Table 4 shows the t-test to determine difference in the pre-test assessment between the Treatment and the Control Group.

Table 4. t-test to determine difference on the Pre-Test Assessment between the Treatment and Control Group

Pre-Test	*Treatment*	*Control*
Mean	11.3925	11.245
Variance	8.793958333	6.4745
Observations	4	4
Hypothesized Mean Difference	0	
Df	3	

t Stat	0.214568154	
t Critical one-tail	2.353363435	
t Critical two-tail	3.182446305	

There is no significant difference on the performance of the students in the four areas of Mathematics between treatment group and the control group in the pre-test assessment manifested on the computed t- value of 0.214568154 which is less than (<) t-critical value one-tail value of 2.353363435 and t-critical two-tail value of 3.182446305, therefore the Null Hypothesis is Accepted.

The data clearly implies on the similarity of the student performance in the pre-test assessment by the two groups of students. Both had experienced difficulty in solving mathematical problems related to addition, subtraction, multiplication and division prior to the conduct of the intervention.

Learning mathematics is a complex and time-consuming endeavor. For many students, mathematics is a frustrating and confusing array of facts, rules, and formulas. The confusion can often be due to the introduction of too many concepts in a short period of time. Students that do not have sufficient time to understand concepts, practice procedures, or solve problems are never likely to obtain a sense of "getting it." What's more, students that do not understand concepts, procedures, and problems rarely maintain the motivation to keep trying (MacGregor, 2013).

The instructional approach of breaking down component skills into manageable chunks, training students to a level of proficiency and moving them forward, celebrating each incremental step along a developmental continuum has proven to be effective in teaching struggling students. Once students have the necessary component skills, they can build up higher order skills (MacGregor, 2013).

Table 5 shows the t-test to determine difference in the post-test assessment between the Treatment and the Control Group.

Table 5. t-test to determine difference on the Post-Test Assessment between the Treatment and Control Group

t-Test: Paired Two Sample for Means		
Post-Test	***Treatment***	***Control***
Mean	22.5925	12.39
Variance	0.695558333	11.04706667
Observations	4	4
Hypothesized Mean Difference	0	
Df	3	
t Stat	7.572227919	
t Critical one-tail	2.353363435	
t Critical two-tail	3.182446305	

There is significant difference on the performance of the students in the four areas of Mathematics between treatment group and the control group in the post-test assessment manifested on the computed t value of 7.572227919 which is greater than (>) t-critical value one-tail value of 2.353363435 and t-critical two-tail value of 3.182446305, therefore the Null

Hypothesis is Rejected.

According to Frawley (2012), timed drills are also an important factor in developing automaticity. "Math fluency is often calculated by determining a student's digits correct per minute for a specific set of facts. Students who possess fluency can recall facts with automaticity, which means they typically think no longer than two seconds before responding with the correct answer" (Frawley, 2012).

Furthermore, Thompson (2017) advocates that automaticity with basic facts leads to increased opportunities for responding. Students who are able to complete basic skills and with ease have more opportunities to practice these skills because it takes them less time to complete each problem and it is also easier to integrate these skills when completing more complex tasks. The faster students are able to complete basic skills the more opportunities they have to practice complex skills; thus, furthering their mathematical knowledge. Likewise, the more opportunities a student has to respond, the greater their skill development. When a student is able to practice to the point of over-learning, they are able to refine their skills in a particular area. Once a student becomes automatic with a set basic math facts, they can claim fluency with those basic math facts (Skinner & Daly, 2010).

CONCLUSIONS

Based on the summary of the investigations conducted, the researcher has concluded that:

1. For the treatment group, the students were assessed in the pre-test assessment "Did Not Meet Expectation" in the areas of subtraction, multiplication and division while "Fairly Satisfactory" in addition and "Outstanding" in addition, subtraction, multiplication and division in the post-test assessment.
2. For the control group, the students were assessed in the pre-test assessment "Did Not Meet Expectation" in the areas of addition, subtraction, multiplication and division while "Fairly Satisfactory" in addition and "Did Not Meet Expectation" in subtraction, multiplication and division in the post-test assessment.
3. There is significant difference on the level of performance between pre-test and post-test assessment for the treatment group while not significant in the control group.
4. There is significant difference on the post-test assessment between the treatment and control group while not significant on the pre-test assessment.

RECOMMENDATIONS

Based on the summary and the conclusions arrived at, the researcher has offered the following recommendations:

1. The use of Timed Practice Drill intervention is strongly recommended in classroom teaching mathematics across all year and grade level for better academic achievement.
2. To conduct an in-service training workshop for teachers' capability building in order acquaint and master on the application of timed practice drill exercise is strongly encourage.
3. Intensify the exercises for Timed Practice Drill for subtraction and division functions in Mathematics for mastery and high competence level.
4. Identify students considered as non-numerates in Mathematics and use Time Drill Practice as school intervention program.
5. To conduct a parallel or similar study with in-depth and wider scope so as to validate and confirm the findings obtained in the study.

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