
Effect of Mnemonic-Aided Instruction on Academic Performance of Maritime Students in Calculus

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Abstract: This paper describes the effect of mnemonic aided instruction on the academic performance of maritime students in Calculus. Specifically, it aimed to determine the level of academic performance of students before and after the intervention when taken as a whole and in terms of the topic areas. Furthermore, it aimed to determine the significant difference between the level of academic performance before and after the intervention when taken as a whole and in terms of the topic areas (Derivative and Integral). A One-Group Pre-test Post-test Quasi-Experimental research design was used to assess the effect of mnemonic aided instruction on the academic performance of maritime students in calculus during the school year 2021-2022. The data were gathered using a researcher-made instrument in order to answer the study's objectives, as reflected in the table of specifications prepared by the researcher, which had undergone validity and reliability testing. Thirty-four (34) maritime students participated in the study, considering they have complete attendance from the administration of test before intervention up to the administration of test after the intervention. The results showed that maritime students got low academic performance in calculus before the intervention and average level of academic performance in calculus after the intervention. This implied a favorable increase in students' level of academic performance when taken as a whole and in terms of the topic areas after they are infused with mnemonic-aided instruction. Furthermore, the Wilcoxon Signed-Rank test results revealed a significant difference between the level of academic performance before and after the intervention when taken as a whole and in terms of the topic areas. From the results, this study emphasizes the need to consider the infusion of mnemonic-aided instruction to improve students' learning through memory retention in calculus, specifically in the topic areas of derivative and integral.

Keywords: Calculus, Derivative, Integral, Trigonometric Functions, Mnemonic-Aided Instruction, Maritime Students, Philippines

1. Introduction

Research has indicated the importance of calculus knowledge for undergraduate programs in science and technology fields [1]. Sonnert and Sadler [2] believe that grades in high school mathematics, including calculus, provide a good predictor of the students' grades in college. Furthermore, Bressoud et al. [3] states that even students with relatively weak preparation in Mathematics appear to benefit from taking a calculus course in these fields. In the same study, he noted that calculus is the only part of what would be required to ensure that all students can reach their potential.

As one of the oldest sciences, mathematics helps us with many maritime affairs' calculations. Differential equations (calculus) solve many problems connected with the navigation and motion

of vessels [4]. In the same study, the number of applications of trigonometric functions was very high. For instance, the triangulation technique is used in astronomy to measure the distance to close stars; in geography, it is used to measure distances between landmarks, and it is also used in satellite navigation systems. The sine and cosine functions are the basis of the theory of periodic functions, such as those that describe sound and light waves. In addition, differential calculus is also used to solve problems in marine engineering and naval architecture [5].

The researcher's teaching experiences during a face-to-face class taught him to use techniques, approaches, and methods in teaching calculus to make learning as easy as possible for the development of the learners, which should also be suited to their interests and individual diversity. Specifically, the researcher experienced teaching calculus to Grade 11 students and found

that few of them could solve and retain their knowledge about calculus. They can perform when an assessment is given after the session of the same day or as a formative assessment. However, they hardly perform calculus when an assessment is given after the unit topic, summative assessment, or even just a few days after the discussion. Perhaps, they have forgotten the process and steps in calculus, specifically in the issues of differentiation and anti-differentiation of trigonometric functions.

Given the present condition, which is an online learning setup, the researcher wishes to infuse mnemonics as a memory retention aid and teaching technique to increase students' academic performance in solving the derivative and integrals of the different trigonometric functions to maritime first-year college students who were not able to take calculus during their senior high school level. A mnemonic device is any learning technique that aids information retention; it also aims to translate information into a form the brain can retain better than its original form [6].

K to 12 curricula began in 2012, incorporating calculus in the high school curriculum under the strands Science, Technology, Engineering, and Mathematics (STEM) and Pre-Baccalaureate Maritime Specialization (PBMS). However, calculus was not a subject in the strands Accountancy, Business, and Mathematics (ABM), Technical, Vocational and Livelihood (TVL), and Humanities and Social Sciences (HUMMS). The researcher saw the need to infuse techniques to address the problem of students in calculus during this online learning. Furthermore, this study seeks to introduce mnemonic-aided instruction to regular students, unlike in other studies where researchers used it for students with learning disabilities.

To fill in the gap in the literature, this study would perform a written test to determine the effects of mnemonic-aided instructions on first-year maritime students. In lieu with this, the study identified the level of academic performance of students in Calculus before and after the intervention. Likewise, the study answered the inferential question, "Is there a significant difference on the level of Academic Performance of students in Calculus before and after the intervention?"

Furthermore, the researcher aims to alleviate the academic performance of students through the help of mnemonic-aided instruction, which in turn would be the basis for developing an instructional workbook in calculus.

2. Framework of the Study

2.1. Theoretical Framework

This study was anchored on the following theories: the Constructivist Theory of Jerome Bruner and the Theory of Cognition by Piaget.

In the Constructivist Theory, Bruner suggested the ability to represent knowledge in three stages: Enactive representation, Iconic representation, and Symbolic representation. As cited in Rita and Corpuz [7], Bruner viewed Iconic representation as a stage in which learning can be obtained using models and pictures. Furthermore, learners in this stage can use mental images to stand for certain objects or events. Iconic representation allows one to recognize objects when they are

changed in minor ways. In the study, iconic representation is when students learn the different integration and differentiation formulas with the help of mnemonics as mental images.

Also, Bruner views symbolic representation as a stage where the learner has developed the ability to think in abstract terms. This uses a symbol system to encode knowledge. Language and mathematical notation are the most common symbol systems [7]. This view of Bruner is related to the study in such a way that the symbol systems imply mnemonics that the students can use to synthesize the different techniques in integration and differentiation.

As cited by Duka in the study of Estonanto [8], Piaget viewed learning as a process that happens following the developmental stages of a person. To this theorist, learning is defined as any change in the behavior of an individual which occurs if new schemata to be learned can be absorbed by the ability of the individual to understand depending on his level of maturity. Only those students who have reached the level of the Formal Operation stage can understand abstract concepts. In other words, students learn new schemata of the differentiation and integration in calculus using mnemonics, and they are ready to grasp concepts of these topics since they have reached the Formal Operation stage.

2.2. Conceptual Framework

Mnemonic aided instruction is an instructional strategy commonly used with students who have disabilities as well as those who are non-disabled. It was made to help you remember important facts. Mnemonic training makes it easier for students to acquire the general education curriculum by providing them with the tools they need to better encode information, making it much easier to recall it afterwards. Mnemonics can be used in mathematics and other subjects [9]. In the same study, Mnemonic instruction not only aids in the retention of multiplication facts but can also motivate other students who have had difficulty learning them. Moreover, Sule and Saporio [10] recommended that intervention strategies to improve calculus should be focused on enhancing academic performance, changing course-related attitudinal problems, and providing sufficient motivation.

In connection with the aims mentioned above and the recommendations of the previous researchers, the researcher gathered different results and linked this to the Philippine Education System, perceiving the need for quality mathematics education to provide for the shape of the future in order to prepare for the next generation for effective learning in a highly technological, complex world of tomorrow. Quality graduates who are products of the highest educational standard are the premise of the Department of Education in defining the thrust of secondary education [11].

In the Senior High School, STEM and Pre-baccalaureate Maritime Specialization students are required to take Basic Calculus as part of the specialized subjects of the strand [11]. In Lenon and Agatep's [12] study, most Computer Learning Center students do not realize the relationship between calculus and their chosen field. They also complained that their curriculum was loaded with many mathematics subjects

and failed to see the link between these two disciplines.

According to Bressoud [3], calculus may not be an appropriate goal for the high school curriculum, especially for those students who will not utilize it for their post-secondary plans. Also, Bressoud mentioned that many students who enroll in calculus in high school were not adequately prepared for calculus when they go to college. Thus, this study aimed to determine the effect of mnemonic-aided instruction on the academic performance of college students in calculus.

The variables of the study were the pre-test and post-test scores of students in written tests, and the mnemonic-aided instruction was the study’s intervention. The variables stated are categorized as independent and dependent variables. The dependent variable was the post-test scores of the students. The researcher considered post-test scores as dependent because it was subjected to the intervention to be done in the group and depended on the extent of the effect of the intervention. Meanwhile, the pre-test score was considered an independent variable because it was not affected by the intervention.

An intervention called mnemonic-aided instruction was done in a face-to-face learning setup. The researcher prepared a power-point presentation in every session that included the learning outcomes, introductory topic questions, motivation, discussion proper (mnemonic-aided instruction), and topic exercises with additional chalk and board materials for further elaboration of the discussions with examples. The pre-test and post-test were done through a printed questionnaire prepared by the researcher.

The study utilized an input, process, and output flow. Specifically, inputs are the pre-test and post-test; the process is the intervention which was mnemonic-aided instruction; finally, the output was the calculus workbook. Two sets of parallel test questionnaires were administered to the same sets of students for the pre-test and post, in which the result of these two sets of parallel tests was compared to determine if there is any significant difference. Furthermore, pre-test and post-test scores were compared to determine if the intervention was found to be effective or not. Lastly, the output calculus workbook focused on the differentiation and anti-differentiation of trigonometric functions was crafted to be used by future students.

The figure below depicted the flow of the study:

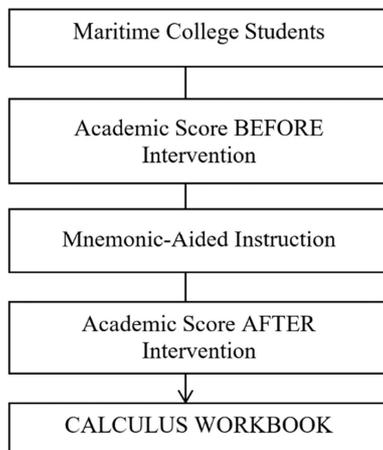


Figure 1. Schematic Diagram.

3. Research Methodology

This section describes the research design, participants of the study, research instrument, experimental procedure, and statistical treatment.

3.1. Research Design

The study utilized a One-Group Pre-test, Post-test Quasi-Experimental research design. According to White and Sabarwal [13], quasi-experimental research designs, like experimental designs, test causal hypotheses. In both experimental and quasi-experimental designs, the program was viewed as an 'intervention' in which a treatment – comprising the elements of the program being evaluated – is tested for how well it achieves its objectives, as measured by a pre-specified set of indicators. A quasi-experimental design, by definition, lacks random assignment, however. Assignment to conditions (treatment versus no treatment or comparison) is using self-selection (by which participants choose treatment for themselves) or administrator selection (e.g., by officials, teachers, policymakers, and so on) or both routes.

3.2. Participants

The participants of the study were a section of undergraduate students at a maritime school who took up Basic Calculus subject because they are non-Science, Technology, Engineering, and Mathematics Students (non-STEM) or non-Pre-Baccalaureate Maritime Specialization (non-PBMS) graduates on their senior high school. Hence, they need this subject as a bridging program on the Maritime Education Department. The number of participants was 34, subjected to the availability of the participants and the number of students who have completed the attendance for the duration of the study. The study utilized a complete enumeration method in selecting the participants.

3.3. Instruments

The study utilized parallel researcher-made test questionnaires for both pre-test and post-test. These questionnaires consisted of 25 items covering topics such as derivatives and integration.

Learning plans were created to guide the researcher on the topics to be discussed per session for the whole eight sessions. The learning competencies were based on the curriculum guidelines the Department of Education set but focused only on trigonometric functions.

The researcher then set a table of specifications to ensure the equal distribution of the subtopics and competencies under the lesson of differentiation and anti-differentiation. The table of specifications made by the researcher was based on the standard institutional format of the maritime school.

The instruments were subjected and evaluated by ten (10) members of the panel of experts to ensure the instruments' validity. This study used content validity to determine the essential items needed based on the table of specifications.

To determine which items are to be retained, each item must surpass the content validity ratio of 0.62, established by Lawshe [14].

At first, the researcher-made 30-item test was subjected to a validity test. Of these 30 items, all were considered valid as they were higher than or equal to the suggested content validity ratio of 0.62 of Lawshe [14]. However, out of 30 valid items, the researcher selected 25 items with higher content validity ratio since five items are considered extra items in case of invalidity of an item for each objective.

Reliability testing of this study was administered to 30 students of the same characteristics as the participants. The statistical tool used in quantifying the internal consistency of the questionnaires was KR20 because the questionnaire has dichotomous responses where they can either get a correct or a wrong answer. The result of the 25-item test for reliability was 0.82, interpreted as reliable.

3.4. Experimental Procedure

This study consisted of three phases: the pre-experimental phase, the experimental phase, and the post-experimental phase. The following was the inclusion of the three phases indicating the steps that were done per phase:

- 1) Phase 1. Pre- Experimental Phase. The researcher had done the initial steps by asking for approval for the conduct of the study from the research ethics committee and securing that all forms were complete. Then, the letter to the Administrator, Dean of College of Maritime Education (CME), and Program Head of CME of was sent requesting approval to conduct the study in the maritime school.
- 2) Phase 2. Experimental Phase. After the proper communication, a validated and reliability-tested pre-assessment test made by the researcher was administered to the participants. After conducting the pre-test, experimentation consisted of eight sessions covering the following topics: Derivative and Anti-derivative of Trigonometric Functions. After the conduct of the experiment, the post-test questionnaire was administered.
- 3) Phase 3. Post-Experimental Phase. Once the post-test questionnaire had been collected, the researcher then checked and counted the scores of students and encoded the raw score to a spreadsheet application for organization and was readied for analysis.

3.5. Statistical Treatment

The data gathered were organized, analyzed, interpreted, and presented using appropriate statistical tools to answer the identified problem.

For objective numbers 1 and 2 which required descriptive statistics, i.e., in determining the level of academic performance of students in calculus during pre-test and post-test, the mean and standard deviation were used. The interpretation of the level of academic performance of students was based on the following scale:

Table 1. Scale and Interpretation.

Mean Ranges			Interpretation
Derivative	Integral	As a whole	
8.81 – 11.00	11.21 – 14.00	20.01 – 25.00	Very High
6.61 – 8.80	8.41 – 11.20	15.01 – 20.00	High
4.41 – 6.60	5.61 – 8.40	10.01 – 15.00	Average
2.21 – 4.40	2.81 – 5.60	5.01 – 10.00	Low
0.00 – 2.20	0.00 – 2.80	0.00 – 5.00	Very Low

For objective number 3 requiring inferential analysis, i.e., in determining the significant difference between the pre-test and post-test scores, it was subjected to a normality test first. If the data favor a normal distribution, such as the Kolmogorov-Smirnov test results in normal data, a t-test was used to test for significant differences between the pre-test and post-test scores. Meanwhile, if the result of Kolmogorov-Smirnov favors non-normal data, the Wilcoxon Signed Ranks test would be utilized in testing for the significant difference between the pre-test and post-test scores of the participants.

4. Results and Discussion

4.1. Level of Academic Performance in Calculus Before the Intervention

Table 2 presents the level of academic performance of students before the intervention. The results revealed that students' academic performance before the intervention was low in two topic areas, such as derivative (M = 2.94, SD = 1.22) and integral (M = 3.94, SD = 1.63). It was further revealed that the same result of a low academic performance was found when their academic performance was taken as a whole (M = 6.88, SD = 1.63). This simply means that before infusing the mnemonic-aided instruction, students were not familiar with the scope of the subject (specifically differential and integral calculus). This can be supported by the fact that students enrolled in the strand Humanities and Social Sciences and General Academic Strand had no Calculus subject as part of their curriculum in their senior high school.

As supported by the study by Casinillo and Aure [15], students may perform well in calculus when they highly favor the subject, and their academic performance in calculus may remain limited by knowledge, interest, and capability. Thus, the study of Padernal and Diego [16] suggested that the curriculum planner may consider restructuring the curriculum of calculus to be aligned with the maritime concepts to prepare students with quality education and be globally competitive in their chosen careers.

Table 2. Level of Academic Performance before the Intervention.

Topic areas	N	No. of items	Mean	SD	Interpretation
Derivative	34	11	2.94	1.22	Low
Integral	34	14	3.94	1.63	Low
As a whole	34	25	6.88	1.63	Low

4.2. Level of Academic Performance in Calculus After the Intervention

Table 3 states the level of academic performance after the

intervention of mnemonic aided instruction when taken as a whole and grouped according to topic areas. Results showed that both topic areas of derivative (M = 4.68, SD = 1.47) and integral (M = 5.71, SD = 1.73) got an average interpretation of academic performance. When taken as a whole, the results yielded to be average the level of academic performance. It was further disclosed that there was an increase in their mean after the treatment, mnemonic-aided instruction. This implies that students have gained mastery and retention of the topics such as derivatives and integrals of trigonometric functions.

Specifically, in comparing the increase between before and after the infusion of mnemonic-aided instruction, in terms of the area of derivative, the results BEFORE intervention (M = 2.94, SD = 1.22) and AFTER intervention (M = 4.68, SD = 1.47) favorably revealed that there is an increase of 1.74 in students' mean scores after they are exposed to mnemonic-aided instruction. Moreover, in terms of the area of integral, there is an increase of 1.77 in students' mean score after the intervention, with M = 3.94, SD = 1.63 (BEFORE) and M = 5.71, SD = 1.73 (AFTER), respectively. Furthermore, when taken as a whole, the students' academic performance levels before the intervention (M = 6.88, SD = 1.63) and after the intervention (M = 10.38, SD = 2.65) revealed an increase of 3.50 in their mean score after mnemonic-aided instruction.

The findings in the experiment of Estonanto [8] supported this study that reveals the use of mnemonic devices in teaching calculus has helped increase students' performance. In addition, the study by Yahya et al. [17] states that mnemonic device involves reorganizing information and are advantageous for students to become more active learners. If students master the practice of how it works correctly, they can perform well the given problem successfully.

Table 3. Level of Academic Performance after the Intervention.

Topic areas	N	No. of items	Mean	SD	Interpretation
Derivative	34	11	4.68	1.47	Average
Integral	34	14	5.71	1.73	Average
As a whole	34	25	10.38	2.65	Average

4.3. Significant Difference in Students' Academic Performance Before and After the Intervention

Table 4 showed a significant difference in students' academic performance before and after the intervention when taken as a whole and in the topic areas. In determining the difference in the academic performance before and after the intervention in terms of the area derivative, the Wilcoxon ranked test results indicated that the performance of students after the intervention (mean rank = 17.90) was more favorably effective than before the intervention (mean rank = 8.08), leading to the decision of rejecting the null hypothesis when taken as a whole (Z = -3.946^b, p-value = 0.000). This means there is a significant difference in the level of academic performance of maritime students in the derivative area before and after they were exposed to mnemonic-aided instruction.

The results further indicated the comparing mean scores before and after the intervention on derivatives. The negative ranks indicated there were six (6) students who had decreased

results after the intervention; the positive ranks indicated that there were twenty-five (25) students who got increased results after the intervention, and ties indicated that there were three (3) students who maintained their scores after the intervention. The results implied that mnemonic-aided instruction did not improve the performance of 17.65% (percentage of negative ranks) of the students in terms of the area of derivatives of trigonometric functions. Furthermore, only 8.82% (percentage of tie ranks) of students viewed that whether the intervention was done or not, the results of their academic performance remained unchanged in terms of the area of derivative. However, the results implied that 73.53% (percentage of positive ranks) of the students supported that mnemonic-aided instruction was effective in aiding them to obtain favorable results in their academic performance in terms of the area of derivative.

The Wilcoxon ranked test results indicated that the intervention was favorably effective, with a mean rank of 17.92 (BEFORE) and 11.43 (AFTER). This result yielded the decision to reject the null hypothesis when taken as a whole (Z = -3.461^b, p-value = 0.001). This means there is a significant difference in the level of academic performance of students in the integral of trigonometric function before and after they were exposed to mnemonic-aided instruction.

The results further revealed that comparing mean scores before and after the intervention in the integral trigonometric function, the negative ranks indicated that there were seven (7) students who had decreased results after the intervention. Meanwhile, ties indicated that two (2) students maintained their scores after the intervention. Furthermore, the positive ranks indicated that twenty-five (25) students got increased results after the intervention. This result recorded that 5.88% (percentage of tie ranks) of students supported that whether the intervention was done or not, the results of their academic performance remained unchanged in terms of the area of integral. However, 20.59% (percentage of negative ranks) of the students supported that mnemonic-aided instruction was not effective in increasing their level of academic performance in terms of the area of integrals of trigonometric functions. Most importantly, the study implies that 73.53% (percentage of positive ranks) of students revealed that mnemonic-aided instruction was effective in aiding them in obtaining favorable academic performance results.

The Wilcoxon Signed ranked test results indicated that the students' academic performance after the intervention (mean rank = 7.00) was more favorable than their performance before the intervention (mean rank = 17.86) when taken as a whole (Z = -4.426^b, p-value = 0.000), leading to the decision of rejecting the null hypothesis. This means that there is a significant difference in the level of academic performance of maritime students before and after they were exposed to mnemonic-aided instruction.

The results further elaborated that when comparing the mean scores of students (before and after the intervention), negative ranks indicated there were four (4) students who had decreased results after the intervention, and the positive ranks indicated that there were twenty-eight (28) students who got

increased results after the intervention. Ties indicated that two (2) students maintained their scores after the intervention. There are 5.88% (percentage of tie ranks) of students who viewed that whether the intervention was done or not, the results of their academic performance remained unchanged. Moreover, 11.77% (percentage of negative ranks) of the

students viewed that mnemonic-aided instruction was not effective in increasing their level of academic performance in Basic Calculus. The results prominently implied that 82.35% (percentage of positive ranks) of students revealed that mnemonic-aided instruction was effective in aiding them to obtain favorable results in their academic performance.

Table 4. Difference in Students' Academic Performance before and after the intervention.

Derivative	n	Mean rank	Sum of Ranks	Z	p-value	Interpretation
Negative Ranks	6 ^a	8.08	48.50	-3.946 ^b	0.000	Reject H ₀
Positive ranks	25 ^b	17.90	447.50			
Ties	3 ^c					
Total	34					

Integral	n	Mean rank	Sum of Ranks	Z	p-value	Interpretation
Negative Ranks	7 ^a	11.43	80.00	-3.461 ^b	0.001	Reject H ₀
Positive ranks	25 ^b	17.92	448.00			
Ties	2 ^c					
Total	34					

As a whole	n	Mean rank	Sum of Ranks	Z	p-value	Interpretation
Negative Ranks	4 ^a	7.00	28.00	-4.426 ^b	0.000	Reject H ₀
Positive ranks	28 ^b	17.86	500.00			
Ties	2 ^c					
Total	34					

a. After intervention < before intervention

b. After intervention > before intervention

c. After intervention = before intervention

5. Summary of Findings, Conclusion, and Recommendations

5.1. Summary of Findings

The level of academic performance of maritime students before the intervention was low in terms of the topic areas derivative and integral and when taken as a whole. However, there was a favorable increase in the results of their academic performance in the topic areas of derivative and integral and when taken as a whole after they were exposed to mnemonic-aided instruction. Specifically, they obtained an average level of academic performance after the intervention.

There is a significant difference in the academic performance between before and after the intervention when taken as a whole and in terms of the topic areas. Given the percentage of students who obtained better scores after the intervention, when taken as a whole, there were 28 out of 34 students in terms of the area of derivatives of trigonometric functions, there were 25 out of 34 students in the area of integral of trigonometric functions, and there were 25 out of 34 students who revealed that mnemonic-aided instruction is deemed effective in increasing their academic performance.

5.2. Conclusion

The students' academic performances were generally low before the intervention and increased to average after mnemonic-aided instruction. The study concluded that

mnemonic-aided instruction in Calculus effectively increased students' academic performance.

The findings of this study conform to the constructivist theory of Jerome Bruner. An iconic representation is that when students recognize the mnemonic-aided instruction, they seem to have better memory retention resulting in favorable academic performance. In symbolic representation, this study indicated that when students have developed the ability to think abstractly, they will no doubt remember the mnemonic-aided instruction since the mnemonic used is the loci-memory placed technique (remembering based on their locations).

Mnemonic-aided instruction has been proven effective in developing students' memory retention and increasing their calculus academic performance. However, a few students could not view mnemonic-aided instruction as effective, considering their learning diversities probably not leaning towards using visual representations such as charts, lines, graphs, and tables.

5.3. Recommendations

Given the results and conclusions, the following are the recommendations made by the researcher:

- 1) Mathematics Teachers. It is recommended that mathematics teachers take the initiative to integrate mnemonic devices on topics where it can be applicable for the students to be able to actively learn and gain positive results from the learnings obtained in the subject, considering the students' diversity.
- 2) Students. It is recommended that students with difficulty

in learning calculus or any mathematics-related subjects should use the power of a mnemonic device to improve their learning in the subject.

- 3) School Administrator. The administration, through the Human Resource Department, may consider providing more opportunities for Mathematics teachers to be trained on the use of mnemonic-aided instruction and other alternative strategies in teaching math and other subjects. Collaborative teaching may also be considered among teachers to improve students' academic performance.
- 4) Future Researchers. It is recommended that future researchers replicate the study using different types of mnemonic devices and should consider the group of students according to their diversity. Moreover, Solomon's four-group experimental research design should be used further to see the effectiveness of mnemonic aided instructions in calculus.

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