Effectiveness of *MnemoPow (Mnemonics Power) Device* in Teaching Limit Theorems of Calculus

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Abstract - *Calculus is oftentimes avoided by most students due to the common notion of its difficulty as a subject. Likewise, some studies revealed that most students find the topics in this subject very abstract to understand. To address these problems, a mnemonic device called MnemoPow (Mnemonics Power) was developed. A quasi- experimental study was conducted in the laboratory high school of one state college in Sorsogon City to evaluate the effectiveness of the proposed mnemonic device. Two classes composed of forty- five (n= 45) students each were involved in this study as controlled and experimental group. The controlled group was introduced to Limit Theorems of Calculus using traditional lecture method while the experimental group was exposed to MnemoPow Device. Results of Pretest and Posttest were tested using t- test at 0. 05 level. Findings revealed that there is a significant difference between the performance of both groups. MnemoPow Device was found to be an effective approach in teaching Limit Theorems in Calculus.*

Keywords: *Mnemonics, MnemoPow, calculus, limit theorem, performance*

INTRODUCTION

Calculus has always been a victim of negative perceptions among Filipino learners. In fact, in a study conducted by Alday and Panaligan [1], it was mentioned that most college students prefer to enroll to courses with lesser mathematics they will encounter; they will avoid if possible higher mathematics subjects like calculus. Educators call this negative attitude of students towards mathematics subjects a math anxiety. Mathematical anxiety is defined by Tobias [2] as a negative psychological behavior of an individual that usually leads to avoidance of mathematical concepts and numbers. Math anxiety is oftentimes blamed by teachers as the root cause of poor achievement of students in math subjects. Students suffering from this anxiety usually experience sweating palms during class recitations in math lectures, shaking hands when taking examinations in math, and extreme avoidance of mathematical concepts. These students are characterized by their very little confidence on their ability to do mathematics and understand numerical concepts, thus oftentimes lead to their decision to take minimum number of math courses and consequently resulted to a limited career choice option [3].

Some of the possible causes of math anxiety are difficulty in understanding math concepts, lack of motivation and study habits, strict teachers and failed major examinations, the congested curriculum in Math, fragile foundations of students in the fundamental skills, lack of appropriate school facilities, and negative attitudes and stereotypes of Filipinos toward Math. Sousa[4] stressed that it is the negative experiences of students in their past that is highly contributory to the development of fear in mathematics (or math phobia) among them. In support to this, Wong [5] said that the over- dependence of teachers on chalk- and- board method in teaching solving equations was the reason of boredom of most pupils in math classes. Since mathematics is already a difficult subject, when taught using traditional "lecture" method leaving the task to students to concretize the abstract, frustration usually follows which later develops into negative attitude towards math. This negative attitude must be eliminated if educators are to target understanding of mathematical skills since right attitude is prerequisite to developing motivation among students which is essential in problem solving. [6]

In order to have better achievement in mathematics education, Lee- Chua [7] stressed that teachers should consider pedagogies that are pro-active, engaging, stimulating and that can provoke the interests of the students. The study of Knuth et al. [8]

and MacGregor and Stacey [9] suggested that students must be exposed to curriculum materials that will support concepts in math and stimulate memory. To produce meaningful experience to learners that will both provide interest and memory- stimulating curricular tasks, mnemonics devices were proposed by educators.

Mnemonics device is defined by Higbee [10] as memory aid that help an individual to remember a concept or an information with the use of a strategy or a technique. In his review of studies conducted to evaluate the impact of mnemonics in teaching mathematics, Manalo[11] concluded that use of mnemonic devices is an effective strategy in teaching elementary mathematics especially when it is coupled with elements of fun.

A study about teaching functions to high school students conducted by Nilsen[12] revealed that mnemonics devices can bridge the gap between the concrete and abstract mathematical concepts during the transition of students from the lower to upper secondary level mathematics. Similarly, Graham [13] found out that computer- based mnemonic illustrations can aid teachers in improving the numerical competencies of high school students with learning disabilities. Another study by Buayan and Balbuena [14] affirmed the positive effect of using mnemonics in introducing mathematical concepts to students. In their study, it was concluded that by using the mnemonics LAUS and LPUN, the performance of students in the lesson Operation on Integers was enhanced.

In high school mathematics, several mnemonic devices are used by teachers to establish principles of solving and evaluating equations. Among these popular mnemonics are the often- used FOIL method, PEMDAS, SOH-CAH-TOA, SSS Theorem, SAS and AAS Theorems. In this study, the researcher introduced and tested the effectiveness of the mnemonic device *MnemoPow (Mnemonics Power)* which is a device used in teaching Limit Theorems in Basic Calculus subject.

THEORETICAL FRAMEWORK

The study is anchored on the following principles and theories of Psychology and learning: Piaget's Theory of Cognition (as cited by Duka [15]), Theory of Multiple Intelligences by Gardner and Meaningful Learning Theory of Ausubel (as cited by Aquino [16]).

Piaget (as cited by Duka [15]) viewed learning as a process that happens in accordance to the developmental stages of a person. To this theorist, learning, which is defined as any change in the behavior of an individual, occurs if the new schemata to be learned is can be absorbed by the ability of the individual to understand depending on his own level of maturity. Only those students who have reached the level of Formal Operation Stage can understand abstract concepts. In other words, students whose pace of mental maturity is slower will tend to find the concept of Limits in Calculus difficult due to its abstract nature as a subject.

In addition, Gardner's Theory of Multiple Intelligences (as cited by Aquino [16]) held that each learner has his own intelligences. The use of mnemonics device would be of great help to both Auditory and Visually- smart learners since it was supposed that majority of Filipino pupils are in this type of learner.

Finally, the insistence of Ausubel on the use of innovative strategies and learning tasks that will make the learning experience meaningful to the learners support this strategy being discussed in this paper. According to his Meaningful Learning Theory, retention of concept in the mind of the learners can only be attained if the learning experience leaves a personal "touch" or "meaning" to the learners. The use of mnemonics device will help the students form new schema.

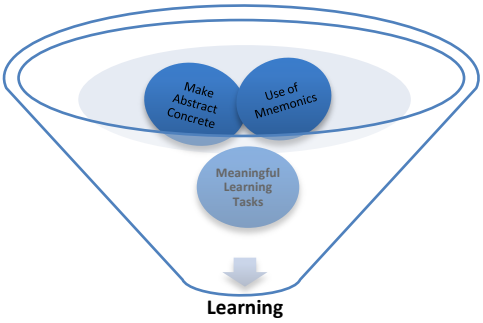

Figure 1. Theoretical Framework

OBJECTIVES OF THE STUDY

This study sought to determine the effectiveness of the mnemonic device *MnemoPow* in teaching Limit Theorems among senior high school students under the Science, Technology, Engineering and Mathematics (STEM) Strand in the subject Basic

Calculus. The specific objectives are: (1)Compare the performance of controlled and experimental group in the lesson Limit Theorems; (2)Test the significant difference between the performance of the controlled and experimental group; and (3)Evaluate the effectiveness of *MnemoPow Device* in teaching Limit Theorems among students.

MATERIALS AND METHODS

The research methodology employed quasi-experimental design. A quasi- experimental study is defined as a research design where two set- ups or groups are being utilized to manipulate certain variables and investigate about their effects on the samples [17]. It is quasi- experimental since two groups of STEM students were involved in the study as subjects. Out of four (4) sections in the laboratory high school of Sorsogon State College in the Philippines, the two heterogeneous sections became the subjects of the study and were treated as the controlled and experimental groups. Each section has forty- five (n= 45) students which results to a total population of one hundred eighty (p= 180). The researcher purposely selected the two (2) sections which has the highest standard deviation because they represent more diverse groups of learners. While the two (2) classes were the subject, the remaining two (2) participated in the try- outs of the teacher- made test prepared by the researcher. The purpose of the study was made known to the respondents and participation was on voluntary basis. Likewise, the researcher ensured the participants of the confidentiality of the results.

A table of specification was prepared by the researcher to secure equal distribution of the subtopics and competencies under the lesson Limit Theorems. After this, a 30- item test was constructed based on the prepared TOS. Two (2) professors who are both experts in the field of mathematics and one (1) laboratory high school STEM teacher were commissioned to validate the test. Some test items were revised based on their comments and suggestions. Dry- run test then was conducted to the two (2) sections after the content- validation. During the first conduct of test, it was observed that 30 minutes is not enough so the duration was extended to 45 minutes. The results of the try- outs suggested discarding items #29 and #16 due to very low difficulty index, and revising items #5 , #13 and #24 since the index of discrimination was low.

To test the effectiveness of *MnemoPow Device*, the controlled group underwent a four- session discussions about the lesson Limit Theorems in the subject Basic Calculus utilizing the traditional chalk-board method, whereas with similar lesson, the experimental group was exposed to Limit Theorems employing the *MnemoPow Device*. Pre-test and post-test were utilized to determine whether the device is an effective approach in teaching Basic Calculus. The device makes use of the mnemonics Lim- Co- is- Co *("the Limit of a Constant is the Constant itself")*, Lim- Va- Sub *("the Limit of a Variable is computed using Substitution")*, Lim- Mul- Va- Fac- Sub *("the Limit of a Multiple- Variable expression is computed by Factoring out the numerical coefficient then multiplication after Substitution")*, Lim- Sum- is- Sum- Lim *("the Limit of Sum is the Sum of the Limits")*, Lim- Dif- is- Dif- Lim *("the Limit of Difference is the Difference of the Limits")*, Lim- Pro- is- Pro- Lim *("the Limit of Product is the Product of the Limits")*, Lim- Qu- is- Qu- Lim *("the Limit of Quotient is the Quotient of the Limits")*, Lim- Ro- is- Ro- Lim *("the Limit of Roots is the Root of the Limits")*, and Lim- Ra- is- An- Ra *("the Limit of a Radical Expression is the Answer of the Radical Expression when evaluated")*. The details on how these mnemonics are being used in evaluating limit expressions will not be discussed in this paper.

The statistical tools utilized in this study were mean percentage score (MPS) and t- test. MPS was computed by dividing the total score by the number of students, then dividing again by the highest possible score. T- test for correlated samples was utilized to test the significance in pretest and posttest of the two groups, while t- test for non- correlated samples for the pretest versus pretest and posttest versus posttest of each group respectively.

RESULT AND DISCUSSION

In order to compare the performance of students who were exposed and not immersed to *MnemoPow Device*, the mean percentage scores (MPS) of both the experimental and controlled groups were analyzed first. After this, the performance of the two groups was tested for significance using t- test.

Table 1 shows the performances of the controlled and experimental groups during the pretest and the posttest. It can be gleaned that both groups displayed a remarkable increase in MPS from pretest to posttest. However, it can also be observed that the

experimental group exhibited a more notable increase in performance as compared to that of the controlled group.

Table 1. Performances of Controlled and Experimental Groups

Group	Mean Percentage Score (MPS)	
	Pretest	Posttest
Control	40. 80	45. 90
Experimental	41. 70	53. 75

While the experimental group registered an increase of 12. 05 in MPS, the control had only 3. 10 difference in MPS. This finding means the use of the mnemonic device *MnemoPow* in teaching Limit Theorems has helped increase the performance of students in the experimental group.

Table 2 . T- Test Result of the Pretest and Posttest of the Controlled and Experimental Groups

Samples	t- value	Tabular value (0. 05)	df	Decision Ho
Both Groups' Pretests	1. 015	1.980	88	Accept
Controlled Group's Pretest- Posttest	2. 576*	2. 021	44	Reject
Experimental Group's Pretest- Posttest	3. 012*	2. 021	44	Reject
Both Groups' Posttests	2. 178*	1.980	88	Reject

*Note: *Significant at 0. 05 level of significance*

Furthermore, Table 2 presents the significant differences among the performances of the controlled and experimental group during their pretest and posttest. One can notice that both the experimental and controlled groups registered significant improvements in their performance. When tested using 0.05 level of significance, the results showed the t- value of the controlled group's pretest- postest 2. 576 exceeded the tabular value 2. 021. Likewise, the t- value of the experimental group's pretest- posttest also registered greater value as compared to its tabular value. These both imply that both groups' respective differences in their MPS were significant; only that the experimental group outperformed the controlled group for a difference of 7.85 MPS. Furthermore this difference in the performance during posttest was found to be significant. Since the t- value 2. 178 exceeded the tabular 1.980, it can be said that the experimental group performed better in the posttest as compared to the controlled group. Meaning, the class who were exposed to *MnemoPow Device* outperformed the students who were taught about Limit Theorems using traditional lecture method. Likewise, it can be said that it was the utilization of the *MnemoPow Device* that helped improved the performance of the experimental group since the difference in performance of both groups during the pretest was not found to be significant since 1. 015 did not exceed the critical value 1. 980. This result is similar to the findings of Balbuena and Buayan [14] in their study about effect of mnemonics device and gaming to academic performance which also reinforced the positive impact of the use of mnemonics device in teaching mathematical concepts- in their case integers.

Thus, based on the results of this study, it can be concluded that using *MnemoPow Device* is an effective approach in teaching Limit Theorems in the subject Basic Calculus for Senior High School. Using this mnemonics device allows students to recall mathematical concepts easily by associating the abstract concept to the mnemonics formed [18]. This strategy enables students to engage in a self- appreciating activity since mnemonics usually establish connections from a schema to a real- world concept where the schema could be linked.

CONCLUSION AND RECOMMENDATION

The experimental group outperformed the controlled group in solving expressions involving Limit Theorems. There is significant difference between the performance of the experimental and controlled group. The use of *MnemoPow Device* is an effective strategy in teaching Limit Theorems in the subject Basic Calculus for Senior High School as supported by the theories of Piaget [15], Gardner and Ausubel [16].

It is recommended that the mnemonics device *MnemoPow* be utilized in teaching Limit Theorems in more STEM classes. Solomon's Experimental Design be used in another study to further strengthen the validity of the results. A broader scope be employed in future studies with the same subject since this study was only conducted in a laboratory school with only four sections.

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