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Effectiveness of Convergent Mastery Technique in Teaching Selected Topics in High School Trigonometry

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ABSTRACT

Trigonometry as a subject can be difficult to comprehend especially on proving identities and solving trigonometric functions. It is important that a teacher must incorporate a teaching style which could help students better comprehend the subject. Convergent mastery technique is a recommended technique for better mastery and comprehension. To provide empirical facts on the effect of convergent mastery technique in teaching Trigonometry to junior-high-school students, this study was conducted. This study used a quasi-experimental design called the pre-test-post-test control design. The participants were the two heterogeneous sections of the third-year level of Stella Maris Academy of Davao. The tool in this study used is a 40-item teacher-made test with 17 items for the topic "The Fundamental Trigonometric Identities" and 23 items for the topic "Verifying Trigonometric Identities." This instrument was used in the pre-test and post-test to measure the achievement of the students both in the experimental and the control group. The data gathered were summarized, translated, and analyzed using the mean scores for both pre-test and post-test. At 0.05 level of significance, the t-test was used to find a significant difference between the experimental and control groups. Findings show the significant difference between pre-test and post-test scores as well as the mean gain scores of

the two groups. Thus, convergent mastery technique is an operational strategy in improving the academic achievement of students and is recommended to be used in teaching mathematics or in any discipline.

Keywords **-** Mathematics Education, effectiveness of convergent mastery technique, high school trigonometry, quasi-experimental design, Davao City, Philippines

INTRODUCTION

The National Council of Teachers of Mathematics emphasizes that the goal of mathematics courses in the United States is not only for students to acquire reliable methods and memorize mathematical procedures. Rather, students must learn with mastery and understanding to produce correct solutions on paper-and-pencil drills and exercises (Weber, 2005). In particular, students should know to explain how and why the steps and techniques they apply are mathematically appropriate. Learners must also justify why mathematical theorems and concepts have the properties that they possess (Weber, 2005). There have not been systematic investigations related to the process on how trigonometry courses are taught. Several researchers have noted, however, that current teaching approaches do not seem geared toward improving and developing students' performance in trigonometry.

In preparatory secondary schools of Jimma Zone, the teaching of trigonometric functions and the learning in general of grade eleven students were not explicitly studied. There are a large number of learners at every grade level who do not perform well in trigonometry. Most students were low achievers in trigonometric identities in particular.

In selected international schools in Bangkok, knowledge skills of students had the least level of academic achievement in Mathematics. The requirement of recalling memorized information is recommended to be developed intensively among students. Remembering a wide scope of material from particular facts to complete and general theories must be given emphasis in teaching mathematics. This involves bringing to students' minds the appropriate information to familiarize procedures and methods (Shaikh, 2013).

Filipino students in general have been seldom noted for mathematical ability. International surveys have placed the country near the bottom, and local studies similarly reflect such performance by students and teachers alike. Branches of

mathematics where Filipinos are coping are Advanced Algebra, Trigonometry and Geometry. The usual difficulty of high school students is that most students had a hard time performing operations involving complex fractions, factoring polynomials, working with word problems, and proving and verifying concepts in trigonometry and geometry.

The grades of junior students of Stella Maris Academy of Davao for the third grading period school year 2011-2012 had drastically decreased. This only proves that trigonometry as a subject is harder than statistics. Statistics was presented during the first and second quarter. With these results, it can be concluded then that the students have a hard time coping up with trigonometry than statistics. Moreover, with further and deeper lessons in trigonometry such as trigonometric identities, it is possible that students would have a hard time coping with the subject.

FRAMEWORK

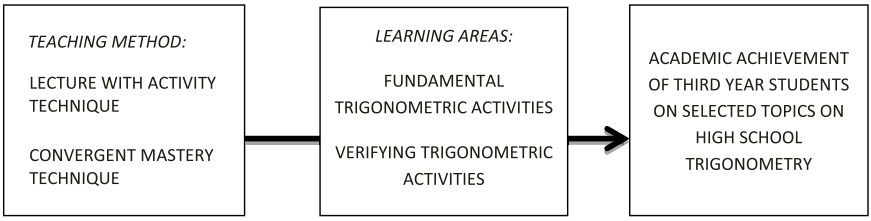

Figure 1. Framework of the Study

The research paradigm above shows the activities of the experimental and control group. The independent variable is the teaching method to be applied in the instruction of the learning areas enumerated. The dependent variable is the academic achievement of the third-year students in selected topics on high school trigonometry.

OBJECTIVES OF THE STUDY

The study aimed to determine if convergent mastery technique could help SMAD students learn more especially in the topic trigonometric identities. This is also to ensure that students have mastered the subject matter as this would be very helpful in further and deeper lessons in trigonometry.

METHODOLOGY

Research Design

This study used a quasi-experimental design called pre-test-post-test control design as further developed by Dimitrov and Rumrill (2003). Its sole purpose is to measure and compare changes from experimental treatments.

Research Site

This study was conducted at Stella Maris Academy of Davao during the fourth grading period of the school year 2011-2012. The participants were the two heterogeneous sections of the third-year level as distributed equally by sophomore teachers based on their second-year performance. The two sections were the III - Justice and III - Love, both composed of 41 students, with 19 boys and 22 girls. There will be one experimental group and one control group, and the assigning was done randomly by tossing a coin.

Instrumentation

A forty-item teacher-made test was used as a tool for this study. It is composed of seventeen items for the topic on fundamental identities and twenty-three items on verifying identities. Subtopics under fundamental identities are reciprocal, quotient and Pythagorean identities. While on verifying identities, factoring and simplifying trigonometric expressions were highlighted.

The researcher made the initial draft of the test instrument along with a Table of Specification to determine the necessary domains. This instrument was used in both the pre-test and at the same time the post-test to measure the achievement of the students both in the experimental and control groups. Pilot testing of the initial draft of the test instruments was conducted to forty fourth-year high school students. The item analysis of the results followed. From the first draft of fifty items, ten were discarded. Again, the remaining 40 items were given to the same group of students.

After which, the validity of the test was established by consulting experts and other mathematics teachers to assess construct and content validity of the items. Their suggestions were considered. The index of reliability test using the SPSS 17 software was done with a result of 0.804.

Data Collection

The following steps were followed in the conduct of the study:

1. Approval from the Principal.
   The researcher asked the approval and permission from the school principal to conduct the study.
2. Scoring of the Pre-test and Post-test
   The following qualitative description or rating were observed in the scoring of the Pre-test and Post-test results:

Range of Mean	Qualitative Description	Level
80 – 100	Outstanding	Denotes very high level of achievement
60 - 79.99	Very Satisfactory	Denotes high level of achievement
40 – 59.99	Satisfactory	Denotes moderate level of achievement
20 – 39.99	Poor	Denotes low level of achievement
0 – 19.99	Very poor	Denotes a very low level of achievement or a failing performance

3. Administering the pre-test to all subjects of the study A pre-test was administered to both groups before the start of the treatment. The content of the pre-test in the experimental group was identical to the control group.
4. Conduct of the Experiment
   After the pre-test, the experiment started. The experimental and control group were taught by the researcher using the same lesson plan. One class have the standard or traditional technique, while one class was given the convergent mastery technique.
5. Giving the Post-test
   After the series of activities designed for the conduct of the experiment, a post-test was administered.
6. Collection of data taken from the Pre-test and Post-test
   The researcher had the data from the pre-test and post-test scores of both the experimental and control groups. It was then analyzed and interpreted.

Table 1. Activities of the experimental and control group

	Activities	
Day	**Experimental**	**Control**
1	Pre-test	Pre-test
2	Discussion/lecture Reciprocal Identities Quiz 1, 2 & 3	Discussion/lecture Reciprocal Identities Board Work & Activity sheet 1
3	Discussion/lecture Quotient Identities Quiz 4, 5 & 6	Discussion/lecture Quotient Identities Board Work & Activity sheet 2
4	Discussion/lecture Pythagorean Identities Quiz 7	Discussion/lecture Pythagorean Identities Board Work
5	Quiz 8 & 9 (Pythagorean Identities)	Activity sheet 3 (Pythagorean Identities)
6	Discussion/lecture Factoring Trigonometric expressions Quiz 10, 11 & 12	Discussion/lecture Factoring Trigonometric expressions Board Work & Activity sheet 4
7	Discussion/lecture Simplifying Trigonometric expressions Using the Fundamental Identities Quiz 13	Discussion/lecture Simplifying Trigonometric expressions Using the Fundamental Identities Board Work
8	Quiz 14 & 15 (Simplifying Trigonometric expressions Using the Fundamental Identities)	Activity sheet 5 (Simplifying Trigonometric expressions Using the Fundamental Identities)
9	Discussion/lecture Verifying Trigonometric expressions Using the Fundamental Identities Quiz 16	Discussion/lecture Verifying Trigonometric expressions Using the Fundamental Identities Board Work
10	Quiz 17 & 18 (Verifying Trigonometric expressions Using the Fundamental Identities)	Activity sheet 6 (Verifying Trigonometric expressions Using the Fundamental Identities)
11	Quiz 19 (Verifying Trigonometric expressions Using the Fundamental Identities)	Verifying Trigonometric expressions Using the Fundamental Identities Board Work
12	Post-test	Post-test

RESULTS AND DISCUSSION

Pre-test Mean Scores of the Experimental and Control Groups

The pre-test mean score of the experimental group in the topic "Fundamental Trigonometric Identities," with subtopics of "Reciprocal, Quotient and Pythagorean Identities," was 5.63 which means poor and denotes low level of achievement. While on the topic "Verifying Trigonometric Identities," with pre-requisite topics in "Factoring and Simplifying Trigonometric Expressions," the experimental group got a pre-test mean score of 6.59 which also suggest poor and low level of performance.

On the other hand, the pre-test mean score of the control group in the topic "Fundamental Trigonometric Identities," with subtopics of "Reciprocal, Quotient and Pythagorean Identities," was 6.46 which signify poor and low level of achievement. While on the topic "Verifying Trigonometric Identities," with pre-requisite topics in "Factoring and Simplifying Trigonometric Expressions," the control group got a pre-test mean score of 7.71 which suggests poor and low level of achievement. The result implies that the respondents have no background or have inadequate knowledge of the subject matter. The students' performance was expected since they have never been taught by their teacher or the researcher of the subject matter yet. This supports the research findings of the National Research Council cited by Weber (2005) that one of the reasons why students have low academic achievement is because of the insufficient prior knowledge they have about the subject matter.

The Post-test Mean Score of the Experimental and Control Groups

The experimental group obtained a post-test mean score of 14.68 for the topic "Fundamental Trigonometric Identities," which means outstanding and denotes very high level of achievement. While on topic "Verifying Trigonometric Identities," the experimental group got a post-test mean score of 12.76 which means satisfactory and moderate level of performance.

On the other hand, the control group got a post-test mean score of 13.93 which also means an outstanding achievement and denotes very high level of achievement. While on topic "Verifying Trigonometric Identities" the control group got a post-test mean score of 11.15 which means satisfactory achievement, denoting a moderate level of achievement.

The result implies that respondents both in the control and experimental group learned outstandingly and satisfactorily in the topics "The Fundamental

Trigonometric Identities" and "Verifying Trigonometric Identities." The techniques applied in teaching the subject matter were both operative in one way or the other since both the experimental and control groups have increased in their academic achievement. The theory of instruction supports that good instruction which includes techniques and strategies could help improve learners' achievement and performance. This includes demonstration followed by practice (Driscoll & Driscoll, 2005). According to the National Council of Teachers of Mathematics (Weber, 2005), the teaching method, techniques and strategies could help students remember, comprehend, solve and analyze the subject matter in a systematic way helping them develop the skills needed.

Table 2. The Post-test mean score of the experimental and control group

	Mean	SD	Interpretation
Post-test experimental (The fundamental Trigonometric Identities)	14.68	2.48	Outstanding, denoting very high level of achievement
Post-test experimental (Verifying Trigonometric Identities)	12.77	3.15	Satisfactory, denoting moderate level of achievement
Post-test control (The fundamental Trigonometric Identities)	13.93	3.32	Outstanding, denoting very high level of achievement
Post-test control (Verifying Trigonometric Identities)	11.15	4.23	Satisfactory, denoting moderate level of achievement

The Mean Gain Scores of the Experimental and Control Groups in Trigonometric Identities

The mean gain score of the experimental and control group in the topic "Fundamental Trigonometric Identities," with subtopics "Reciprocal, Quotient and Pythagorean Identities," are 9.05 and 7.46 respectively which is equivalent to 53.23% and 43.90% in terms of mean percentage gain.

Moreover, the mean gain score of the experimental and control group in the topic "Verifying Trigonometric Identities," with pre-requisite topics in "Factoring and Simplifying Trigonometric Expression," are 6.17 and 3.44 respectively which is equivalent to 26.83% and 14.95% in terms of mean percentage gain. As observed, the mean gain score of the experimental group in the topic "Fundamental Trigonometric Identities" was higher than the mean gain score of the control group in the same competency.

Table 3. The mean gain scores of the experimental and control groups in the same topics in trigonometric identities

Topic	Experimental Group			Control Group		
	Mean (Pre-test)	Mean (Post-test)	Mean Gain Score	Mean (Pre-test)	Mean (Post-test)	Mean Gain Score
The Fundamental Trigonometric Identities	5.63	14.68	9.05	6.46	13.93	7.46
Verifying Trigonometric Identities	6.59	12.76	6.17	7.71	11.15	3.44
Total	**12.02**	**27.46**	**15.44**	**13.88**	**25.07**	**11.20**

Furthermore, the mean gain score of the experimental group in the topic "Verifying Fundamental Identities" was higher than the mean gain score of the control group in the same learning area. The traditional style, which is the lecture and activity combined, also improved the academic performance of the students. The mean gain score of experimental group attests to the effectiveness of convergent mastery technique. There was a higher increase of academic achievement for the experimental group compared to the control group.

This further implies that the convergent mastery technique is effective in improving the academic performance of students. The heart of the strategy is a series of short quizzes that could help students learn more about different learning competencies. Students also learn how to correct their mistakes (Thomas, Brunsting & Warrick, 2010). The study of Norton (2013) is also in agreement with the use of frequent or daily assessment in classrooms. Daily assessment can be in the form of short quizzes at the end of every discussion. Short quizzes that are done every day can significantly improve students' mathematics achievement.

The use of effective convergent mastery technique has a positive impact in teaching trigonometry. The respondents exhibited improvement and development in their academic performances especially in the areas of fundamental and verifying trigonometric identities. It is inferred that the reason short quizzes can and does improve academic achievement is because learner is frequently being exposed to explicit and specific information; therefore, students are enhancing their memory recall skills. One more benefit of constant exposure to quizzes is

that it improves the retention rate of learners. They cannot easily forget things that have been asked to recall from them over and over again (Norton, 2013).

The Independent T-test of the Pre-test Scores of the Experimental and Control Groups

The independent t-test of the pre-test scores of the experimental and control groups in the topic "Fundamental Trigonometric Identities" with subtopics "Reciprocal, Quotient and Pythagorean identities" and the topic "Verifying Trigonometric Identities" with pre-requisite topics in "Factoring and Simplifying Trigonometric Expressions", were shown in Table 3.

The computed t-value for the pre-test mean scores of experimental and control groups in the topic "Fundamental Trigonometric Identities" was -1.92. While the computed t-value of the pre-test mean scores of the experimental and control groups in the topic "Verifying Trigonometric Identities" was -2.33. The pre-test results of the two groups were not significant while their post-test results were significant. The null hypothesis which states that there is no significant difference between the pre-test mean scores of the experimental and control groups in the first learning competency was accepted. While on the second learning area, there is already a significant difference.

Table 4. Independent T-test of the Pre-test Mean Scores of the Experimental and Control Groups

		Levene's Test for Equality of Variances		t-test for Equality of Means		
		F	Sig.	T	df	Sig. (2-tailed)
The Fundamental Trigonometric Identities	Equal variances assumed	2.11	.15	-1.92	80	.058
Experimental and Control Group Pre-test Scores	Equal variances not assumed			-1.92	76.51	.058
Verifying Trigonometric Identities	Equal variances assumed	1.66	.20	-2.33	80	.022
Experimental and Control Group Pre-test Scores	Equal variances not assumed			-2.33	76.89	.022

The findings entail that the experimental and control groups have the same level of understanding in the topic "Fundamental Trigonometric Identities." On the other hand, the result shows that the experimental group might have a prior understanding compared to the control group in the topic "Verifying Trigonometric Identities."

The Pre-test and Post-test Mean Scores of the Experimental Group

The experimental group got a computed t-value of -20.18 in their pre-test and post-test mean scores in the topic "Fundamental Trigonometric Identities" and -11.27 in "Verifying Trigonometric Identities." Result shows that both are significant at = 0.05. Along with this result is the rejection of null hypothesis which states that there is no significant difference between the pre-test and post-test mean scores of the experimental group in the topic "Fundamental Trigonometric Identities" and the topic "Verifying Trigonometric Identities." The experimental group has improved since from poor achievement in the pre-test for the topics "The Fundamental Trigonometric Identities" and "Verifying Trigonometric Identities" up to an outstanding and satisfactory achievement as attested in their post-tests. The improvement of the respondents' academic performance is credited to the idea of the effectiveness of convergent mastery technique as emphasized by Thomas, Brunsting and Warrick (2010).

Table 5. Paired Sample Test of the Pre-test and Post-test Mean Scores of the Experimental Group

	Mean	Paired Differences			T	Df	Sig. (2-tailed)
		SD	Std. Error Mean				
P A I R 1	Pre-test Experimental (The Fundamental Trigonometric Identities) Post-test Experimental (The Fundamental Trigonometric Identities)	-9.05	2.87	.45	-20.18	40	.000

P	Pre-test Experimental						
A	(Verifying Trigonometric						
I	Identities)						
		-6.17	3.51	.55	-11.27	40	.000
R	Post-test Experimental						
	(Verifying Trigonometric						
2	Identities)						

The Pre-test and Post-test Mean Scores of the Control Group

The computed t-value for the pre-test and post-test mean scores of the control group for "Fundamental Trigonometric Identities" was -14.44 while for "Verifying Fundamental Identities" was -4.47. Result shows that both are significant at = 0.05.

The null hypothesis which states that there is no significant difference between the pre-test and post-test mean scores of the control group in the topic "Fundamental Trigonometric Identities" and "Verifying Trigonometric Identities" was rejected. It also means that the traditional technique in teaching Mathematics in Stella Maris Academy of Davao (SMAD) is valuable and operative since it has improve significantly the achievement of the respondents for the learning competencies "The Fundamental Trigonometric Identities" and "Verifying Trigonometric Identities" respectively. Though, there has never been a thorough study of the effect of the lecture with activity approach, the result shows a positive impact on the achievement of the students that are alike as well with the incorporation of the convergent mastery technique.

Table 6. Paired Sample Test of the Pre-test and Post-test Mean Scores of the Control Group

		Paired Differences			t	Df	Sig. (2-tailed)
	Mean	SD	Std. Error Mean				
P A I R 1	Pre-test Control (The Fundamental Trigonometric Identities) Post-test Control (The Fundamental Trigonometric Identities)	-7.46	3.31	.52	-14.44	40	.000
P A I R 2	Pre-test Control (Verifying Trigonometric Identities) Post-test Control (Verifying Trigonometric Identities)	-3.44	4.92	.77	-4.47	40	.000

The Independent T-test of the Mean Gain Scores of the Experimental and Control Groups in Trigonometric Identities

The independent t-test summary for the mean gain scores of the experimental and control group in the topics "Fundamental Trigonometric Identities" with subtopics "Reciprocal, Quotient and Pythagorean Identities," and "Verifying Trigonometric Identities," with pre-requisite topics in "Factoring and Simplifying Trigonometric Expressions," are shown in Table 7. The computed t-value for the mean gain scores of the experimental and control group in the first area, "Fundamental Trigonometric Identities" was 2.32 while the computed t-value of the mean gain scores of the experimental and control group in the second area, "Verifying Fundamental Identities" was 2.89. Result shows that both are significant at = 0.05. The null hypothesis stating there is no significant difference between the mean gain scores of the experimental and control group in "Fundamental

Trigonometric Identities" and "Verifying Trigonometric Identities" were rejected. The significant difference would be in favor of the experimental group. The mean gain score of the experimental group in "The Fundamental Trigonometric Identities" and "Verifying Trigonometric Expressions" are 9.05 and 6.17 while the mean gain score of the control group in the same areas are 7.46 and 3.43 respectively.

Table 7. Mean gain scores of the experimental and control group in the same topics of trigonometric identities

F		Levene's Test for Equality of Variances		t-test for Equality of Means		
		Sig.	T	Df	Sig. (2-tailed)	
Mean Gain Scores in "The Fundamental Trigonometric Identities"	Equal variances assumed	.51	.48	2.32	80	.023
	Equal variances not assumed			2.32	78.44	.023
Mean Gain Scores in "Verifying Trigonometric Identities"	Equal variances assumed	4.54	.04	2.89	80	.005
	Equal variances not assumed			2.89	72.27	.005

Table 7 shows that the achievement of the experimental group, based on the mean gain scores from where the significance of the difference was observed, was better-compared to the other group. Hence, the results are in agreement with the study of Shirvani (2009) stating that by means of quizzes especially when done frequently and often leading to the correction of the mistakes of the students would significantly increase students' mathematic achievement. Moreover, this is being strengthened by other research studies (Shirvani, 2009) indicating that frequent testing helps in improving the academic achievement of the learners. In their study, they have found out that students taking daily quizzes outscored the students taking weekly or those who were seldom given quizzes.

The use of LCD projectors has aided the researcher in giving short quizzes. The short quizzes used in experimental group are in congruence with the activities done by the control group. A reliability test and expert validity check

was administered in the pre-test and post-test tool. A comprehensive application of the technique can also be applied which involves longer time; however, the study only adapted the regular time schedule which was two hours per week for the topic trigonometric identities of the third-year curriculum. The researcher chose to select only one year level.

CONCLUSIONS

The experimental and control groups have improved in their academic performance on selected topics in high school trigonometry. Their performances both got outstanding and satisfactory level of rating respectively in each learning area. The lecture with activity and convergent mastery technique are both effective methods of instruction. However, the experimental group has a higher mean gain score compared to the control group. It was then found out that their mean gain scores have a significant difference. Convergent mastery technique is more effective compared to the lecture with activity technique.

RECOMMENDATIONS

High school teachers or even College Instructors administering Mathematics subjects must consider the use of convergent mastery technique in teaching selected topics in Trigonometry.

Variations in the use of the convergent mastery technique and lecture with activity approach can also be considered as a technique in teaching mathematics or any other disciplines that require mastery of the subject competencies since both were found to be helpful and useful in improving the academic achievement of the students.

School administrators must consider teachers' training on the use of convergent mastery technique to further develop teachers' skills in teaching various disciplines.

Further studies must be considered in incorporating convergent mastery technique in the teaching-learning process especially in other disciplines that need deeper mastery.

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