Effectiveness of Tri-In-1 Strategic Intervention Materials For Grade 9 Students Through Solomon Four-Group Design

Asia Pacific Journal of Education, Arts and Sciences
Vol. 4 No.1, 79-86
January 2017
P-ISSN 2362-8022
E-ISSN 2362-8030
www.apjeas.apjmr.com

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Date Received: October 24, 2016; Date Revised: January 15, 2017

Abstract - *Mathematics, as a highly sophisticated yet practical discipline, provides a person with opportunities to develop life and practical skills. Learning its concepts becomes easier with the aid of various instructional materials (IMs) which are necessary for the teaching-learning process since they address the diverse needs of learners. Strategic Intervention Material (SIM) is a user-friendly IM that can be answered solely by a student or by a group of students inside or outside the classroom. This study determined the effectiveness of the developed Tri-in-1 SIM for grade 9 Mathematics through Solomon Four-Group Design using a total of 60 subject participants that underwent matching under the quasi-experimental method of research. The SIM is incorporated with two-dimensional manipulatives and is composed of different activity cards about the parts of a right triangle, proportions of the corresponding parts of similar triangles, geometric mean in a right triangle and word problems involving right triangle similarity theorem. The study revealed that when students are exposed to Tri-in-1 SIM, their Mathematics achievements are better and higher (F=46.306, P<0.05). Tri-in-1 SIM is more effective in teaching right triangles than using the Mathematics Learner's Material 9. Another SIM with two-dimensional manipulatives entitled Make It Right is proposed for the next lessons. IMs that are tailored based on the actual students' aptitude could be more effective than the materials that are designed for the national level. Teachers are encouraged to make SIM with two-dimensional manipulatives that suit their students' learning ability to elicit utmost academic performances.*

Keywords: *effectiveness, strategic intervention material (SIM), Solomon Four-Group Design, instructional material (IM), manipulatives*

INTRODUCTION

In this globally competitive world, education plays a significant role in every individual's life. Through education a person is equipped with the necessary knowledge, attitude and skills needed for life-long learning and for employment. Mathematics, as a highly sophisticated yet practical discipline, provides a person with opportunities to develop life and practical skills. Lewis [1] believed that learning to think in mathematical terms is an essential part of becoming a liberally educated person. However, Mathematics has always been regarded as the most misunderstood subject.

National Center for Education Statistics [2] revealed that in Mathematics, only minority of students reached the proficient level and at least one-third of students did not reach the basic level in each grade level. Some western countries like Canada, France, Germany, Ireland, Norway and New Zealand marked performance differences in various content areas of mathematics making their overall performance low. Likewise, the Philippines' Mathematics Education shows similar results as the country ranked 30th out of 42 countries (TIMMS, 1995) and 41st out of 45 countries (TIMSS, 2003) that joined the Mathematics Evaluation in Asia.

Furthermore, Filipino students ranked lower than as expected in the High School Readiness Test and in the National Achievement Test (NAT) for Secondary particularly in Mathematics subject (Mendoza, 2006). Having 75% as the passing rate, National Educational Testing and Research Center (NETRC) disclosed the results which were: 50.70% for S.Y. 2004 – 2005, 47.82% for S.Y. 2005 – 2006 and 46.73% for S.Y. 2011 – 2012. Furthermore, NETRC presented the performances of Bicol Region and Sorsogon City Division for school year 2006 - 2007 and 2007 - 2008. The data showed deteriorating mean percentage scores of the Region as 32.2% and 31.7% respectively. Sorsogon City Division ranked from 102nd to 124th out of the 191 City Divisions in the Country.

In Sorsogon City Division, Sorsogon National High School (SNHS) is considered a premier secondary school due to structure, enrolment and its scholastic record of producing graduates who are now outstanding in various fields. But despite being the leading secondary school, its Mathematics NAT results were unstable. In fact, for the past three consecutive years, the School's percentage score for school years 2012 - 2013, 2013 - 2014 and 2014 - 2015 were 37.27%, 52.15% and 34.79% respectively.

Learning environment is considered one of the factors as to why these disparaging mathematics national achievement test results happen. Higgins et. al [3] emphasized that physical elements like inadequate temperature, control, lighting, air quality and acoustics in the learning environment have detrimental effects on concentration, mood, well-being and attendance of learners.

In the case of SNHS, the School's Main Building was destroyed due to fire last February 2014. Shifting classes were implemented because it is the expedient solution to address the lack of classrooms. The shifting class schedule is still implemented in spite of the repair of the Main Building as another building of the School was demolished. As a consequence, the quality of Education, especially of Mathematics is compromised. The Head Teacher III of the Mathematics Department agreed that the teaching-learning process is affected as proven by the poor performances of students in Mathematics.

Due to classroom and time constraints, competencies in the Curriculum Guide are not taught within the school year. In Grade 9 Mathematics, most of the third grading topics such as right triangles are discussed but not entirely covered during the fourth grading period. These topics, according to some grade 9 Mathematics teachers, are some of the difficult topics encountered by students.

Thus, upon taking Grade 10 Mathematics, students lack the prerequisite knowledge and skills. It's because Grade 9 topics and competencies are essential for students to adopt with the spiral progression learning curriculum. Unfortunately, this scenario is also true in the lower grades.

Mathematics teachers then are expected to find ways to avoid this kind of circumstances to happen again. They have to look for alternative measures on how to expedite the teaching-learning process without compromising the quality of Education.

Section 2 Article IV of the Code of Ethics for Professional Teachers [4] mandates that every teacher shall make the best preparation for the career of teaching. Hence, appropriate learning or instructional material may be utilized during their classroom instruction.

Instructional material is a learning tool that helps the learners to learn faster and better. Dahar [5] explained that the use of appropriate instructional materials has a strong relationship to the academic performance of secondary students. Barlis [6] also added that instructional materials play an important role in improving students' Mathematics achievement.

Togonon [7] clarified that strategic intervention material (SIM) is a type of instructional material that deepens students' skills in manipulation, thinking, understanding and observing. It's a user-friendly instructional material that can be used inside the four corners of the classroom or it can be given as a take home activity of students. SIM can be answered solely by a student or by a group of students through cooperative learning. Even the Department of Science and Technology (DOST) recommends the use of SIM not only for remediation but in teaching large classes as well. The Department of Education (DepEd) also suggests the utilization of SIM in enhancing the academic achievement of students who are performing low in Science and Technology including Mathematics.

The versatility and effectiveness of strategic intervention materials without manipulatives were already been proven by a number of studies. Soberano [8] affirmed that her SIM was effective in helping her students in mastering the competency-based skills in Chemistry. Dy [9] recommended that her developed SIM may be adopted as instructional material to facilitate learning and to improve the academic achievement of students in Science. Lumogdang [10] used SIM in commercial cooking and she found out that the performance of her students had improved. Bruma [11] also found her SIM effective in teaching "Pagsulat sa Filipino 7". In Mathematics, Lagata [12] concluded that SIM is an effective instructional tool in solving word problems. Doctama [13] stated that there was a positive transfer of knowledge in simplifying rational algebraic expressions using her SIM. Gatdula [14] developed and validated a SIM on rational algebraic expressions. Her study proved that the SIM is effective in improving the performance of students at Castillejos National High School, San Roque Castillejos Zambales.

Corollary, instructional materials [15] that integrate concrete manipulatives in classroom instruction improve students' achievement. Siemon et.al [16] believed that working with these concrete objects will lead to greater conceptual depth. Stein &

Bovalino [17] agreed that manipulatives are essential tools in helping students to think and reason in more meaningful ways. Stein [17] added that students easily remember what they did and explain what they were thinking when they used manipulatives in solving a problem.

Guevara [18] acknowledged that the use of manipulatives makes mathematical concepts visual and concrete since it is a hands-on learning experience. Furthermore, Marshall and Swan [19] enumerated the benefits of using manipulatives in the classroom. Some of these are: the use of manipulatives provides hands-on learning, manipulatives appeal to all styles of learning and manipulatives engage students in building a better understanding of the topics being taught.

These benefits are rooted to the constructivist learning theory, cognitive learning theory and the theory of multiple intelligences. Hein [20] believed that constructivist theory is based on the idea that each learner individually constructs meaning as he or she learns. In addition, McLeod [21] stated that in Piaget's cognitive development, learners construct an understanding of the world around them then experience discrepancies between what they already know and what they discover in their environment. On the other hand, Armstrong [22] emphasized the importance of presenting the lessons in a wide variety of ways so that each child has the opportunity to learn in ways harmonious with their unique minds. Integrating manipulatives in a strategic intervention material gives the learners the liberty to construct their own knowledge instead of relying on to someone to do it for them. Hence, the learners become independent and actively involved in the process of making meaning and knowledge rather than passively receiving them from other sources.

The abovementioned studies are the reason why the researcher improved her developed "Tri-in-1" SIM on right triangles and incorporated manipulatives in it. Furthermore, the improvement is also the product of the comments and suggestions given when her SIM underwent validation and acceptability during the 4th Bicol Patiribayan Festival in Baao, Camarines Sur last December 2014. Hence, the researcher would like to test if Tri-in-1 SIM is really effective in improving the Mathematics achievement of learners.

OBJECTIVES OF THE STUDY

This study determined the effectiveness of Tri-in-1 SIM for grade 9 students. The following are the specific objectives: 1) Determine the percentage score in the pretest of the control and experimental groups; 2) Test the significant difference between the percentage score of the two groups in the pretest; 3) Determine the percentage scores in the posttest of the four groups; 4) Test the significant difference between the percentage scores in the pretest and posttest of the control group and the experimental group; and 5) Test the significant difference among the percentage scores in the posttest of the four groups.

METHODS

Quasi-experimental method with matched subjects was used in identifying the 60 grade 9 students that will serve as respondents of this study. Fraenkel and Wallen [23] stressed that in a quasi-experimental design, pairs of individuals may be matched on certain variables to ensure group equivalence and to avoid its possible effect on the study. This is when random assignment is impossible because subjects are in intact groups. Normally, school authorities do not allow classes to be dismantled so that they can be re-constituted for the purpose of the research [24] thus only allows this research method [25].

Solomon Four-Group Design, one of the most rigorous and prestigious design which can be utilized in both true experimental and quasi-experimental studies [26], was likewise adopted in this study. This design is a combination of the pretest-posttest control group design and the posttest-only control group design. Hence, in grouping the 60 students from four different sections namely: Magnesium, Tin, Iron and Titanium of SNHS for the school year 2015-2016, they were assigned to control group with pretest (CG_1), control group without pretest (CG_2), experimental group with pretest (EG_1) and experimental group without pretest (EG_2) respectively.

Table 1. Frequency Distribution of Respondents

Groups	f	Sections	Instructional Material Used
CG_1	15	Magnesium	Mathematics Learner's Material 9
CG_2	15	Tin	Mathematics Learner's Material 9
EG_1	15	Iron	Tri-in-1 SIM
EG_2	15	Titanium	Tri-in-1 SIM

Legend: CG_1 - Control Group with Pretest, CG_2 - Control Group without Pretest, EG_1 - Experimental Group with Pretest, EG_2 - Experimental Group without Pretest

These sections were under the researcher's supervision and were informed that the data gathered from the lesson will be used in this study and will be treated with confidentiality and anonymity. The control groups used the Mathematics Learner's Material 9 while the experimental groups utilized the Tri-in-1 SIM in learning the concepts about right triangles. Table 1 shows the number of subjects, the sections and the instructional material used in each group.

Pretest scores were initially considered in the selection of the subjects for the control and experimental groups with pretest. Fraenkel and Wallen [23] emphasized that pretest provides the researcher with a means of checking whether or not the groups are similar. In matching the subjects for the groups without pretest and the groups with pretest, their average from first to third grading grades in mathematics is considered. These are the variables taken into consideration in ensuring that the subjects in each group were equivalent to each other. Adjustments and modifications can be made by the researcher in grouping the subjects in a Solomon Four-Group Design [26].

The developed Tri-in-1 SIM and a validated teacher-made test were used as instruments. The data gathered were statistically analyzed through the mean, percentage score, t-test, F-test and Scheffés Test. Shuttleworth [27] stated that these tools allow statistical analysis of the results and figures after integrating individual case studies.

The mean was used in determining the percentage scores of each group of respondents in the pretest and posttest. The computed percentage score was transformed into the transmuted grade using the transmutation table of the DepEd Order No. 8, s.2015 also known as Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program[28]. The percentage scores in the pretest and posttest of the group of respondents were reported using the descriptors as identified by the same DepEd Order.

The t-test for independent groups was used to determine if there is a significant difference between the percentage scores of the control and experimental groups in the pretest. The t-test for dependent samples was used to determine if there is a significant difference between the percentage scores in the pretest and posttest of the control group and experimental group. F-test was used to determine whether or not there is a significant difference among the percentage scores in the posttest of the four groups. Broto [29] recommended the use of Scheffés test to determine where the significant differences lie among the four groups.

RESULTS AND DISCUSSION

Table 2. The Percentage Scores in the Pretest of the Control and Experimental Groups

Groups	PS	TG	Description
CG_1	38.22%	69%	Did Not Meet Expectations
EG_1	37.33%	69%	Did Not Meet Expectations

Legend: CG_1 - Control Group with Pretest, EG_1 - Experimental Group with Pretest

Table 2 presents the percentage score in the pretest of the control and experimental groups. These percentage scores (PS) were transformed into transmuted grades (TG) with its corresponding descriptions.

The percentage scores in the pretest of the control and experimental groups were 38.22% and 37.33% respectively. These percentage scores were both equal to 69% when transmuted. The transmuted grade indicated that both the control and experimental groups did not meet the expectations in answering the questions about right triangles.

The samples in the control group find it hard in answering numbers 1, 3 and 10 which talk about the parts of right triangle and word problems involving right triangle similarity theorem. On the other hand, the experimental group encountered difficulty in answering numbers 4, 6 and 11 which cover the proportions of the corresponding parts of right triangle and word problems involving right triangle similarity theorem. The overall averages of the control and experimental groups were 5.733 and 5.600 respectively which means that their understanding about right triangles is on the same unfavorable level. Furthermore, the studies of Bruma [11] and Guevara [18] elicited similar results. In their studies, they found out that both the control and experimental groups performed poorly during the pretest.

Table 3. Difference between the Percentage Scores of the Two Groups in the Pretest

Statistical Bases	Statistical Analysis
df	28
Level of significance (α)	0.05
t critical value	2.048
t computed value	0.205
Decision on H_0	Do not reject
Conclusion	Not significant

Table 3 shows the difference between the percentage score of the two groups in the pretest.

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Furthermore, the table also revealed the statistical bases and the analysis of the results.

It can be seen from the table that the computed t-value of 0.205 was lesser than the t-critical value of 2.048 at 0.05 level of significance with 28 degrees of freedom. This means that the hypothesis is not rejected. Therefore, the percentage scores of the control and experimental groups in the pretest do not have significant difference.

Table 2 also supports this result. The table shows that the percentage scores of the two groups are almost the same and their transmuted grades are equal. The studies of Fajardo [30] and Namasaka, Mondoh and Keraro [31] had the same result as the present study. Hence, the studies revealed that in the pretest there was no significant difference between the percentage scores of the control and experimental groups. Thus, the learning abilities of the samples in the two groups were homogenous.

Table 4. The Percentage Scores in the Posttest of the Four Groups

Groups	PS	TG	Description
CG_1	61.78	76%	Fairly Satisfactory
CG_2	49.78	72%	Did Not Meet Expectations
EG_1	92.44	95%	Outstanding
EG_2	89.78	93%	Outstanding

Table 4 presents the percentage scores in the posttest of the four groups, namely: control group with pretest, control group without pretest, experimental group with pretest and experimental group without pretest. These percentage scores were changed into transmuted grades. The corresponding descriptions of each transmuted grade were also included in the table.

The table shows that the control group with pretest had a 61.78 percentage score which means that the groups' performance is fairly satisfactory. The control group without pretest had a 49.78 percentage score which falls under did not meet the expectations. The experimental group with pretest had a 92.44 percentage score which means that the groups' performance is outstanding. While the experimental group without pretest had an 89.78 percentage score that is equivalent to an outstanding performance.

Based on the table, both the experimental groups elicit an outstanding performance compared to the two control groups. This result is further supported by Lumogdang [10], Dy [9] and Soberano [8]. Their studies have proven that the experimental group which was exposed to SIM performed better than those in the control group.

Table 5. Difference between the Percentage Scores in the Pretest and Posttest of the Control Group and Experimental Group

Statistical Bases	Statistical Analysis	
	Control Group	Experimental Group
df	14	14
Level of significance(α)	0.05	0.05
t critical value	2.145	2.145
t computed value	5.664	19.197
Decision on H_0	Reject	Reject
Conclusion	Significant	Significant

Table 5 shows the difference between the percentage scores in the pretest and posttest of the control group and the experimental group. Statistical bases and analysis of the results were also presented.

The t-computed value of 5.664 is greater than the t-critical value of 2.145 at 0.05 level of significance with 14 degrees of freedom. This means that the hypothesis is rejected. Hence, there is a significant difference between the percentage scores in the pretest and posttest of the control group.

The table also shows that the t-computed value of 19.197 is greater than the t-critical value of 2.145 at 0.05 level of significance with 14 degrees of freedom. The result suggests that the hypothesis is rejected. Hence, there is a significant difference between the percentage scores in the pretest and posttest of the experimental group.

Table 5 combines the results of tables 2 and 4. Table 5, however, showcases the usefulness of Mathematics Learner's Material 9 and Strategic Intervention Material with Two – Dimensional Manipulatives since both of them promotes learning in Mathematics. Guevara [18] supports this result. Her study revealed that both the control and experimental groups improved in their posttest performances. Barlis [6] further supports this result because based on her study, the use of instructional materials helps in improving the scholastic performance of learners. Therefore, using either of the two instructional materials enhances the academic performances of learners in right triangles.

Table 6 shows the difference between the percentage scores in the posttest of the four groups. The statistical bases and the analysis of the results were also presented.

It can be observed that the F-computed value of 46.306 was greater than the F-critical value of 2.769 at 0.05 level of significance with 3 and 56 degrees of freedom. Thus, the hypothesis was rejected. Meaning

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to say, there was a significant difference among the percentage scores in the posttest of the four groups.

Table 6. Difference among the Percentage Scores in the Posttest of the Four Groups

Statistical Bases	Statistical Analysis
df	3, 56
Level of significance (α)	0.05
F critical value	2.769
F computed value	46.306
Decision on H_0	Reject
Conclusion	Significant

This result is further supported by Table 4 wherein it clearly shows that the percentage scores of the four groups during the posttest vary from 49% to 92%. The study of Namasaka, Mondoh and Keraro [28] also revealed that there was a significant difference among the four groups in their study. On the contrary, Bruma [11] had a different result. In her study, she found out that there was no significant difference among the mean scores of her four groups.

Nevertheless, in order to determine as to where the significant difference lies among the four groups, Scheffés Test was used. Table 7 showed the Scheffés test comparison of the percentage scores in the posttest of the four groups and the interpretation.

Table 7. Scheffés Test Comparison of the Percentage Scores in the Posttest of the Four Groups

Between Groups	F'	(F.05)(K-1)(2.77)(3)
EG_1 vs CG_1	49.34*	8.31
EG_1 vs EG_2	0.37	8.31
EG_1 vs CG_2	95.50*	8.31
CG_1 vs EG_2	41.13*	8.31
CG_1 vs CG_2	7.55	8.31
EG_2 vs CG_2	83.94*	8.31

**Significant*

The table shows that the performances of both the experimental groups and both the control groups did not have significant difference in their performances. This means that the samples exposed to SIM performed at the same higher level while the samples exposed to the MLM 9 performed at the same lower level. Table 4 supports this when it described the performances of the two experimental groups as outstanding while the performances of the two control groups were at the fairly satisfactory and did not meet the expected competency level.

Therefore, even if the use of textbooks can improve the performance of students, still, the use of strategic interventional material with two-dimensional manipulatives produces an outstanding scholastic progress of learners. Hence, using the Tri-in-1 SIM is more effective than using the Mathematics Learner's Material for Grade 9.

CONCLUSION AND RECOMMENDATION

Based on the findings, the following conclusions were drawn: The percentage scores of the control and experimental groups showed that the students did not meet the expected competencies in right triangles during the pretest; the control and experimental groups performed at the same level during the pretest; the percentage scores of the experimental groups during the posttest were higher than the control groups; the percentage scores of both the control and experimental groups significantly improved in the posttest; the use of Strategic Intervention Material with Two - Dimensional Manipulatives was more effective in teaching right triangles than using the Mathematics Learner's Material 9; and instructional materials that are tailored based on the actual students' aptitude are more effective in improving the academic performances of students than the materials that are designed for the national level.

From the conclusions, the following are recommended: Mathematics teachers should be sensitive in identifying the needs and difficulties of diverse learners prior to the lesson proper; Mathematics teachers should incorporate culturally responsive instruction like music, sports and student-centered stories that are relatable to the students; Mathematics teachers should innovate or use available instructional materials to help the students in learning the topics to be taught; Mathematics Learner's Material 9 or the Strategic Intervention Material with Two – Dimensional Manipulatives may be used to improve the mathematics achievement of students; Mathematics teachers may use the Tri-in-1 SIM in order to promote and achieve higher level of academic performances from students; another SIM with two-dimensional manipulatives entitled "Make It Right" is proposed that may be used by grade 9 students in learning the next topics of right triangles; and further studies on the utilization of SIM with two or three dimensional manipulatives that covers the least mastered competencies in Mathematics may be conducted at the Division level to enrich the findings and conclusion of this study.

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