

A MODIFIED 'METHOD COMBINATION THERAPY' AS INSTRUCTIONAL STRATEGY FOR TEACHING SECONDARY SCHOOL GEOMETRY AND EFFECTS ON STUDENTS' ACHIEVEMENT AND RETENTION IN MATHEMATICS

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ABSTRACT

This study investigated the effects of teachers' use of a modified Method Combination Therapy whose components include multiple activities and the use of study questions as instructional strategy for teaching geometry, on secondary school students' achievement and retention of learned concepts. Four research questions and four research hypotheses guided the study. The design was quasi-experimental with a population size of 3400 Senior Secondary One (SS1) students. The sample size was 72 comprising 40 males and 32 females in intact classes. A researcher made Mathematics Performance Test (MPT) with reliability coefficient $r = .87$ was used for data collection using Kuder-Richardson 21 formula. Data was analyzed using Analysis of Covariance (ANCOVA) and the hypotheses tested at $p \leq .05$. Findings revealed that the modified Method Combination Therapy (MCT) adopted in the experiment significantly enhanced students' achievement and retention of acquired knowledge of geometry over time. Consequently, it was recommended among others that teachers in schools could adopt the modified MCT for the teaching of geometry in schools.

Introduction/Background

The idea of a modified Method Combination Therapy (MCT) arose from criticism received on the earlier work titled Method Combination Therapy (MCT) as an instructional strategy for teaching secondary school geometry. Colleagues at the Faculty of Education had observed that the use of games such as Pack to Palace (Awodeyi, 1999), (Ibe, 2004), (Ikafia, 2006) or any other games whatsoever may be refreshing to students but may be boring to those students who are above average in their knowledge of geometry. There was also the criticism that playing the games for motivation during a 40 minutes lesson might not be time friendly. The use of study questions were however suggested in place of games. The popularity of this suggestion among lecturers and teachers of mathematics brought the current modified therapy. The template used in the present study is exactly the same as the one used for the earlier 'Method Combination Therapy'.

The perennial poor performance of students in Mathematics at external examinations in Nigeria is worrisome. The current situation in which students in the schools persistently score low at external or school examinations is unacceptable (Ale, 2003; Obodo, 2004; Buhari, 2006 and Ifamuyiwa, 2007). In the May/June 2015 West African Senior School Certificate Examination (WASSCE) for example, the result released on 11th August, 2015, by the Head of National office of the West African Examination Council (WAEC) reported that 61% of all candidates in the examination failed Mathematics. The remaining 39% that passed include those candidates who obtained ordinary pass in the subject whereas, the minimum requirement for admission into science, engineering and technology at the tertiary level is a credit pass in mathematics.

There are several factors responsible for this poor situation. These include the phobia for mathematics by students, uninspiring mathematics teaching, the dearth of mathematics teachers generally in the country and more (Obioma, 2004; Erukoha, 2005; Ogwuche, 2002). Learners' had also been reported to be exposed to inadequate mathematics experiences in the early formative stages of life and this had affected them in later life in school mathematics (Awodeyi, 1999; Fakuade, 2000). However, this present study is based on the assumption that the mathematics teacher is one of the most important factors in the success or failure of students. Students' outcome depends on the effectiveness of the teachers' method of teaching.

There are several methods of teaching in the classroom. Corwin (2011) listed some of these methods as: direct instruction, question and answer, discussion, mental modeling, discovery learning and inquiry. Eric (2013) appeared to re-brand these methods of teaching as teaching styles thus: authority or lecture styles, demonstration or coach style, facilitator or activity style, delegator or group style, and hybrid or blended style. In addition to these, some researchers have pointed out that games may be used as a method to give students 'drill and practice' on knowledge or concept already formed through class activities. Examples of such games are Pack to Palace or Ludo (Awodeyi, 1999); Snake and Ladder or Algebraic Snadder Joint Game (Ibe, 2005); Trilogudo (Ikafia, 2006) and Mathematical Palace Game (Udo, 2016). Every game is guided by rules of operation, such that students' response to questions on knowledge or concept attracts point score. When a student correctly responds to questions, he scores points and when answer is wrong he loses points. In so doing, it is possible to

determine the winner of the game among two or more players within a specific time frame. Game(s) also serves as a motivator to students.

A teacher may use a combination of these methods or techniques in the course of a single lesson and this depends on his instructional flexibility or dexterity. All the teacher need do is to structure his lesson(s) adequately). Isaac (2011) calls the lesson plan that accommodates two or more methods of teaching a strategy. The teacher should remember that it is one thing for a student to acquire knowledge through activities but it is a different thing for knowledge so acquired to remain with the learner or extinct for lack of drill and practice. The poor performance of students in Secondary School mathematics has reached a level we may call an illness. The illness requires treatment. A Method Combination Therapy (MCT) can be administered as a possible remedy. In a MCT, as many methods of teaching as possible that are students' activity oriented are combined together. The MCT is therefore a strategy that is learner centered. Games too are essentially for ensuring effective drill and practice which in turn aids retention and recall of knowledge among students. It is suspected therefore that if a MCT is used by the teacher to develop concepts for students, and games follow to offer drills and practice, then students will be better off in mathematics learning. For this reason, the present study is designed to empirically investigate the effects of the use a Method Combination Therapy (MCT) on students' mathematics learning.

School mathematics in Nigeria is organized in themes. These are: number and numeration, algebraic processes, geometry, statistics and calculus. The extent to which a Method Combination Therapy will make the teaching of these themes effective is the concern the present team of researchers. The therapy is bound to vary from one theme of topics to another.

Gender difference in mathematics learning has been a recurring issue in education circles. The males were sometimes said to be superior (Alio and Harbour-Peters, 2000; Galadima, 2003; and Ifamuyiwa, 2007). There is also the argument that male superiority over females is not real (i.e. virtual) because the females only see mathematics as a domain of the males (Fenema and Sherma, 1978; Fenema and Carpenter, 1981; Awodeyi and Harbour- Peters, 2000). It is worthwhile to check how the gender argument will play out under a Method Combination Therapy.

Definition of Method Combination Therapy (MCT) as it Applies to School Geometry

In operational terms, Method Combination Therapy is a strategy that is used for teaching mathematics in Secondary School mathematics. It involves using various methods in which activities are the main components for developing mathematical concepts, and the use of game(s) for drill and practice. The following are steps in MCT as it applies to geometry:

- Constructing the nets of 2-dimensional objects to specification (in the current study a cylinder and a cone).
- Folding the nets to shape by joining the ends with masking tape.
- Measuring with a ruler or a tape-rule to ensure accuracy (in this case of cylinder and cone both should be of same height and on same base).
- Experimenting and recording to find out the number of cones filled with sand that will completely fill up the cylinder.
- Formulating the equation that connects the objects, e.g. the relationship between the volume of a cone and volume of cylinder.
- Applying the formula obtained to solve live problems, making generalisation and inference to volume of other types of pyramid whose base is rectangular.
- Using study questions (in lieu of games) to do drills and practice to aid remembering and recall.

The choice of school geometry in this particular experiment is informed by the fact that students have problems learning certain geometry topics. Mensuration is one of such topics in geometry. For example, the teaching of "mensuration" requires students to determine the relationship between objects, such as the sector of a circle and the curved surface area of cone carved out from it.

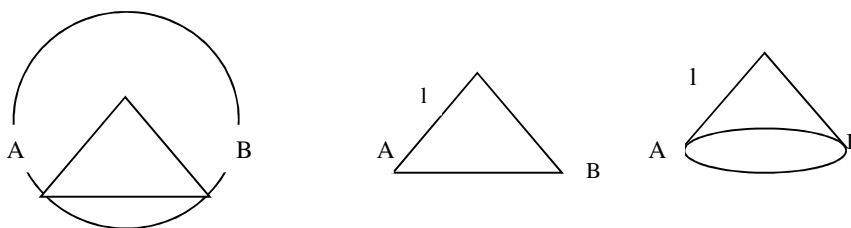


Figure1.

The centre of the circle is at 'O', and the slanting side OB is denoted by l.

$$\text{Area of the minor sector AOB} (\Delta) = \frac{\pi r^2 \theta}{360^\circ} \dots \dots \dots \alpha$$

The curved surface area of the cone = πR β (Rich, 1963)

Teachers are expected to guide students to see the relationship between the lengths of the minor segment AB of the circle and the circumference of the circular based cone AOB. This may be achieved by carrying out the necessary construction work using the set of students' mathematical instruments. The relationship between radius 'AO' of the circle and the slanting height 'l' of cone AOB should also be verified as equal in dimension. At a higher cognitive level, the determination of the relationship between the volume of a cylinder and the volume of a cone which are of the same height and on the same base (Figure 2) requires a higher cognitive thinking and processes compared with Figure 1. The new task requires constructing, verifying, experimenting, and exercise. These are activity based. This is a way the mathematics teacher may fulfill the requirement of the cognitive, the affective, and the psychomotor domains of students learning.

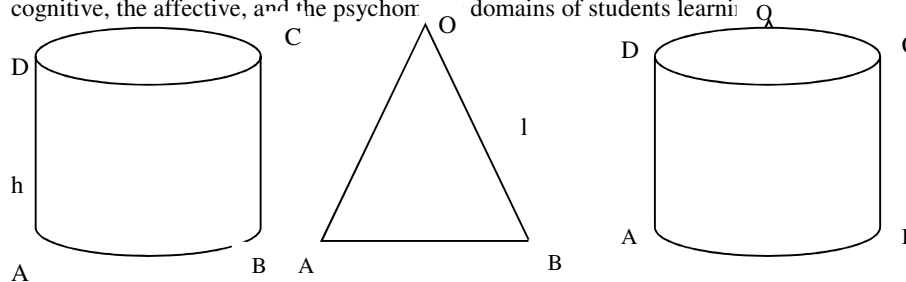


Figure 2.

Volume of cylinder = Base area x Height, and Volume of cone = $\frac{1}{3}$ x Base x Height.

The Problem of the present Study

Many teachers still use 'teacher centered' techniques in schools. In their mathematics lessons, teachers have been observed to introduce lessons by providing learners with sets of formulae; use the formulae to solve examples of related problems for students; and finally issue out practice exercise to students to do, using the teachers' example as template. These steps are typical of a lecture method or what is sometimes called the traditional method or still, what some authors call the expository method. Unfortunately, this procedure hardly gives students the required conceptual knowledge that is required to solve related problems. There is a need therefore to provide a template of a well defined Method Combination Therapy as a strategy for lesson delivery in geometry.

Purpose of the Study

The purpose of the present study was to investigate how the Method Combination Therapy earlier developed for teaching geometry in schools may be modified, by making use of study questions in the place of games. Specifically, the objectives of the study are:

1. To compare the achievement of students on the concept of mensuration when taught using modified Method Combination Therapy (MCT) and when taught using the expository method.
2. To determine the difference in students' achievement by gender when taught mensuration using the modified Method Combination Therapy.

3. To determine the difference in students' retention scores when taught mensuration using the modified Method Combination Therapy and when taught using the expository method.
4. To compare the retention scores of students by gender when taught mensuration using the modified Method Combination Therapy.

Research Questions

The following research questions were raised to guide the study:

1. What is the difference existing between the mean achievement scores of students who were taught the concept of mensuration using the modified Method Combination Therapy and when taught using the expository method?
2. What is the difference existing between the mean achievement scores of students by gender when taught the concept of mensuration using the modified Method Combination Therapy?
3. What is the difference existing between the mean retention scores of students who were taught the concept of mensuration using the modified Method Combination Therapy and using the expository method?
4. What is the difference existing between the mean retention scores of students by gender when taught the concept of mensuration using the modified Method Combination Therapy?

Research Hypotheses

The following null hypotheses were formulated to help answer the research questions:

1. There is no significant difference ($p \leq 0.05$) between the mean achievement scores of students who were taught the concept of mensuration using the modified Method Combination Therapy and using the expository method.
2. There is no significant difference ($p \leq 0.05$) between the mean achievement scores of students by gender when taught the concept of mensuration using the modified Method Combination Therapy
3. There is no significant difference ($p \leq 0.05$) between the mean retention scores of students who were taught the concept of mensuration using the modified Method Combination Therapy and using the expository method.
4. There is no significant difference ($p \leq 0.05$) between the mean retention scores of students by gender when taught the concept of mensuration using the modified Method Combination Therapy.

Research Method:

The design of the study was quasi- experimental. It was carried out in Uyo Local Government Area (LGA) of Akwa Ibom State, Nigeria. The population of all Senior Secondary Schools class one (SSS1) students in the LGA was 3400. One secondary school was randomly sampled for the study from among the existing 55 in the LGA. Also, two intact classes of the SSS1 class were randomly sampled for the study. The sample size was 72. **Instructional materials** used in the study were cardboard sheets, masking tape, smooth White Sea Sand (WSS), the set of students' mathematical instruments, and pair of scissors. **Activities** in which students were involved in the study include the **construction** of cylinder and cone using cardboard sheets. The dimensions of the constructed geometric forms were such that the height of the cylinder and the cone are exactly the same. The circumference of the base of cone is also the same as that of the cylinder. The number of cones of sand that filled the cylinder was determined **experimentally**. **Observations** were made and data recorded. Students could state the **conclusion** that the volume of cone is one-third of the volume of the cylinder. The teacher guided students to infer that same result holds for pyramids on a square or rectangular base.

Lesson plan and notes: A lesson plan for teaching the topic was structured to contain three lessons of 40 minutes each. The two intact classes were randomly assigned into experimental and control groups. Separate lesson notes were prepared for the groups with applicable distinct features, though content taught were exactly the same in both groups.

The experimental group was facilitated to carry out activities stated earlier. In addition, the group played the Mathematical Palace Game (Udo, 2016) with a set of structured study questions. The purpose of the game was to motivate students to aid their remembering of facts and recall of formula. The control group were taught the same content as in the experimental group. The expository method essentially followed steps characteristic of lecture method i.e. providing students a chart of pictures/diagrams of cone, cylinder, cone and cylinder filled with White Sea Sand; a list of formulae for students; giving worked examples, and finally issuing out structured study questions on the topic to students to do for practice in class.

Results

Research Question One: What is the difference existing between the mean achievement scores of students who were taught the concept of mensuration using the modified Method Combination Therapy and using the

expository method? This research question was answered using data in Table 1.

Table 1: Descriptive Statistics of Students' Post-test Scores with Pre-Test Scores as Covariate by Teaching Strategy and by Gender.

Variable	Dimension	N	X	Std. Error	Mean diff. by Dimension
Method	MCT ^a	44	52.465 ^a	3.331	15.685
	Expository	28	36.780 ^a	4.104	
	Total	72	46.365 ^a	3.717	
Gender	Male	27	56.860 ^a	3.983	8.790
	Female	17	48.070 ^a	5.255	
	Total	44	48.239 ^a	4.619	

- a. Covariates appearing in the model are evaluated at pre test =12.97
- Modified Method Combination Therapy with Study Questions

In Table1, the mean achievement score of the 44 students (irrespective of their gender) who were taught using the modified Method Combination Therapy was 52.465^a with a standard error of 3.331. The corresponding mean score of the 28 students taught using the expository method was 36.780^a with a standard error of 4.104. The symbol 'a' appearing as a superscript in the two means indicates that the covariate used with post test are evaluated at pre test = 12.97. The difference between these two mean scores is 15.685.

Research Question Two: What is the difference between the mean achievement scores of students by gender when taught the concept of mensuration using the modified Method Combination Therapy? This research question was answered still on Table 1.

On Table 1, there were 27 male students in the group of students taught mensuration using the modified MCT and their mean achievement score was 56.860^a with a standard error of 3.983. Also, the mean achievement score of the 17 females in the group was 48.070^a with a standard error of 5.255. All means are obtained using pre- test scores of mean = 12.97 as covariate. The difference between the mean achievement scores of males and females is therefore 8.790.

Research Question Three: What is the difference existing between the mean retention scores of students who were taught the concept of mensuration using the modified Method Combination Therapy compared with the expository method? This research question was answered using data in Table 2.

Table 2: Descriptive Analysis of Students' Retention-Test Scores with Pre-Test Scores as Covariate by Teaching Strategy and by Gender.

Variable	Dimension	N	X	Std. Error	Mean diff. by Dimension
Method	MCT ^a	44	50.234 ^a	3.229	9.550
	Expository	28	40.684 ^a	3.978	
	Total	72	46.520 ^a	3.603	
Gender	Male	27	53.345 ^a	3.861	6.223
	Female	17	47.122 ^a	5.094	
	Total	44	50.940 ^a	4.477	

- a. Covariates appearing in the model are evaluated at pre test =12.97
- Modified Method Combination Therapy with study questions

In Table 2, the mean retention score of the 44 students (irrespective of gender) who were taught using the modified MCT strategy was 50.234^a with a standard error of 3.229. The mean score of the 28 students taught using the expository was 40.684^a with a standard error of 3.978. The symbol 'a' appearing as

superscript in all means indicates the covariate used with the post test are evaluated at pre test = 12.97. Hence, the difference between the mean scores of students in the two groups is 9.550.

Research Question Four: What is the difference existing between the mean retention score of students by gender when taught the concept of mensuration using the modified MCT strategy? This research question was answered on Table 2.

On Table 2, there were 27 male students in the group of students taught mensuration using the modified MCT and their mean retention score in the group was 53.345^a with a standard error of 3.861. Also, there were 17 females in the group and their mean retention score is 47.122^a with a standard error of 5.094. Both means are obtained using pre test = 12.97 as covariate. The difference between the mean retention scores of males and females is 6.223.

Hypotheses:

Hypothesis One: There is no significant difference ($p \leq 0.05$) between the mean achievement scores of students who were taught the concept of mensuration in geometry using the strategy involving active learning with a game and using the expository method. This hypothesis was tested and the results shown in Table 3.

Table 3: ANCOVA Analysis of Students Post Test Scores by Method and by Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6559.256 ^a	4	1639.814	3.849	.007
Intercept	32768.236	1	32768.236	76.915	.000
pretest	163.086	1	163.086	.383	.538
method	3460.921	1	3460.921	8.124	.005
gender	699.700	1	699.700	1.642	.204
method * gender	84.372	1	84.372	.198	.658
Error	28544.244	67	426.033		
Total	193588.000	72			
Corrected Total	35103.500	71			

a. R Squared = .187 (Adjusted R Squared = .138).

In Table 3, the computed F value for students' achievement by method of teaching is 8.124 (row5, col.5). The significance of F at 5% probability level is .005 (row5, col.6). Method is therefore significant. In other words, the observed difference between mean achievement scores by groups as show earlier on Table 1, is not by chance.

Hypothesis Two: There is no significant difference ($p \leq 0.05$) between the mean achievement scores of students by gender when taught the concept of mensuration using the moderated MCT strategy. This hypothesis was tested and the result is shown in Table 3.

On Table 3, the computed F value for gender is 1.642 (row 5, col.5). The value of significance of F is .204 ($p \leq 0.05$). Gender is not significant. The observed difference between the mean scores of male and female students as observed earlier in Table 1 is therefore due to chance.

Hypothesis Three: There is no significant difference ($p \leq 0.05$) between the mean retention scores of students who were taught the concept of mensuration using the moderated MCT strategy and using the expository method. This hypothesis was tested and the result is shown in Table 4.

Table 4: ANCOVA Analysis of Students Retention Test Scores by Method and Gender

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2574.372 ^a	4	643.593	1.607	.183
Intercept	35053.347	1	35053	87.550	.000
pretest	96.410	1	96.410	.241	.625
method	1282.890	1	1282.890	3.204	.078
gender	94.053	1	94.053	.235	.629
method * gender	240.892	1	240.892	.602	.441
Error	26825.572	67	400.382		
Total	188260.000	72			
Corrected Total	29399.944	71			

a. R Squared = .088 (Adjusted R Squared = .033)

On Table 4, the computed F value for students' retention of knowledge by method is 3.204 (row 5, col.5). The significance of F ($p \leq .05$) is .078 (row 5, col.6). Method Combination Therapy is surprisingly not significant. The difference earlier observed between the two means on Table 1, which was to the advantage of the moderated MCT might have occurred by chance.

Hypothesis Four: There is no significant difference ($p \leq 0.05$) between the mean retention scores of students by gender when taught the concept of mensuration using the moderated MCT strategy. This hypothesis was tested and the result is shown in Table 4.

In Table 4, the computed F value for students' retention of knowledge when taught using the Method Combination Therapy (MCT) by gender, was .235 (row 5, col. 5). The computed significance of F was .629 (row 5, col.6). Gender is therefore not significant. In other words, males and females are equal in ability to recall acquired knowledge over time.

Summary of Findings

1. Students who were taught geometry using the moderated Method Combination Therapy performed significantly better than their counterparts taught using the expository method. In every 100 trials using the moderated Method Combination Therapy there would be only five chances of error.
2. The moderated Method Combination Therapy surprisingly did not significantly affect students' retention of acquired knowledge, over time. However, there are only seven chances in 100 that the moderated Combination Therapy may not affect students retention.
3. There was no significant gender difference between the achievement scores of males and females at the post test following the use of the moderated Method Combination Therapy.

Discussion of the Findings

The moderated Method Combination Therapy as investigated in this study took two unique procedures. The first was the use of sequenced activities to develop the concept of mensuration, among students. Secondly, the use of study questions to enhance drill, practice, retention and recall of knowledge.

The effects of the use of moderated Method Combination Therapy (MCT) on students were subsequently compared with when the expository method was used. The moderated MCT was significantly superior to the expository method. This result agrees with Isaac (2011) that the use of instructional strategy in which two or more activity based instructional methods are involved would bring about greater achievement among learners as against using one rigid method. Furthermore, this finding agrees with other previous finding that when a combination of methods are blended in a strategy with the teacher facilitating and students responding, the better for students achievement (Adeniran, 1994; Awodeyi, 1999; Akinsola and Animasahun, 2008; Alemu, 2010; Ogwuche, 2012). The Method Combination Therapy also favoured retention and subsequent recall of knowledge previously learnt as the difference between the mean achievement scores of the two groups of students was significant.

Also compared were male and female students within the group taught with the moderated Method Combination Therapy. First, at post test, the males and females were equal in their achievement. This finding is at variance with Alio and Harbour-Peters (2000), Galadima (2003), and Ifamuyiwa (2007) that males were superior to females in mathematics learning. This non difference between the achievement of males and females, may be attributed to the effect of the use of the moderated Method Combination Therapy. The result however agrees with Fenema and Sherma (1978); Fenema and Carpenter (1981); Awodeyi and Harbour- Peters (2000) that any observed difference between achievement of males and females in mathematics learning, to the advantage of males was due to the view of the females that mathematics is a domain of the males. At the retention level, mean test scores did not show a significant difference between the mean achievement scores of males and females. The reason for this is not immediately known.

Conclusion

This study has discovered that a moderated Method Combination Therapy (MCT) which involves the structuring of lesson plan and notes with sequenced activities including the use of suitable study questions will sufficiently facilitate students' academic achievement, retention and recall of knowledge in geometry. The method also facilitated both males and females adequately without bias. The moderated MCT that structures the activities of students to involve: constructing, folding, measuring, experimenting, formulating, applying, generalizing and also employing the use of study questions; is good enough to fill the gap discovered in the teaching of mathematics generally and in the teaching of geometry in particular.

Recommendation

1. Serving teachers should be encouraged to adopt the modified Method Combination Therapy for the teaching of geometry.
2. Proprietors of schools should encourage their teachers to attend workshops to refresh and become conversant with new methods of teaching geometry such as the Method Combination strategy.

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