EFFECTS OF PEER-TUTORING AND COMBINED EXPLICIT AND SYSTEMATIC INSTRUCTION STRATEGIES ON STUDENTS' RETENTION IN MATHEMATICS

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Abstract
The study was conducted to find out effects of Peer-Tutoring (PT) and Combined Explicit and Systematic Instruction (CESI) Strategies on Students' Retention in Mathematics. Quasi-experimental design was used. The sample consisted of 162 Senior Secondary School Students from Edo State. Three Procedural instruments: CESI, PT and Conventional Method (CM) were used while Mathematics Achievement Test (MAT) and Students' Attitude Towards Mathematics Questionnaire (SATMQ) were used for data collection. Seven hypotheses were tested and data were subjected to Analysis of Covariance. Results revealed that there were significant main effects of instructional strategy on retention in the following order: CESI, CM and PT. Among others, it was recommended that teachers should use CESI strategy to enhance retention in Mathematics.

Introduction

Mathematics serves as foundation to many subjects such as Physics, Electronics, Chemistry, Geography and Biology (National Teachers' Institute, 1983). The knowledge of Mathematics makes the fundamental principles of the many science and social science subjects clearer. For example, without Mathematics, the important formulae and equations in Physics, Electronics

and Chemistry cannot be easily explained. The genetic combinations in Biology are better explained with the help of probability in Mathematics.

Mathematics teachers in Nigeria have been experiencing one form of difficulty or another and there is a widespread public concern about the results being obtained primary and secondary school Mathematics examinations (Oyedeji, 1992). Evidence of poor performance of Nigerian students abound in the yearly results being published by WAEC and NECO in Secondary School Mathematics. All the results indicate consistent high failure rates in students' performance in external examinations (Oyedeji, 2006).

Evidence also abound that in Nigeria that the demand for formal education with the concomitant increase in school enrolments, have resulted in a dramatic increase in class sizes, with attendant high teacher-pupil ratio (Bilesanmi-Awoderu, 2012). Bilesanmi-Awoderu, (2012) also disclosed that although the recommended teacher-pupil ratios are 1:30 for primary and 1:35 for secondary schools, observations in many States in Nigeria revealed between 1:50 and 1:85. Sa'ad, Adamu & Sadiq (2014) also pointed out that overcrowded Mathematics classrooms comprised one of the causes of poor performance in secondary schools Mathematics.

In view of the foregoing assertions in connection with overcrowded classes, the researchers found that Combined Explicit and Systematic Instruction (CESI) Strategy, and Peer Tutoring (PT) strategy are very effective in teaching science related subjects like Basic Science (Olagunju & Babayemi, 2014). Also, not much work or study have used CESI and PT for teaching Mathematics in Nigerian Secondary Schools. Hence, this study investigated the use of CESI and PT to effect students' retention of Mathematics concepts. In addition, gender and attitude towards Mathematics were considered in the study as moderator variables.

Horvath (2011) defined Peer Tutoring(PT) as the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions. According to the researcher, it involves people from similar social groupings who are not professional teachers helping each other learn and learning themselves by so doing. Peer Tutoring may consist of students of the same learning level working together or students of varying learning levels working together. This can be easily implemented even in a classroom of diverse learners (Horvath, 2011).

According to Doabler, Cary, Jungiohann, Clarke, Fien, Baker, Smolkowski and Chard (2012), in a recent practice guide, the institute of Education Sciences, (IES) recommended that math interventions should provide explicit and systematic instruction when teaching struggling learners. The practice guide indicated that the level of empirical evidence supporting

this recommendation was strong for raising mean achievement levels of at-risk learners. Doabler, et al. (2012), contended that many learners would benefit, if core math instruction also provides explicit and systematic instruction.

The following hypotheses guided this research:

- There is no significant effect of treatment (PT strategy, Combined Explicit & CESI strategy and Conventional Method (CM)) on retention of Mathematical concepts taught to students.
- There is no significant effect of gender on students' retention of Mathematics concepts after exposure to treatment (PT strategy, CESI strategy and CM).
- There is no significant effect of attitude towards Mathematics on students' retention of Mathematics concepts after exposure to treatment (PT strategy, CESI strategy and CM).
- There is no significant interaction effect of treatment and gender on students' retention of Mathematics concepts.
- There is no significant interaction effect of treatment and attitude towards Mathematics on students' retention of Mathematics concepts.
- There is no significant interaction effect of gender and attitude towards Mathematics on students' retention of Mathematics concepts.
- There is no significant interaction effect of treatment, gender and attitude towards Mathematics on students' retention of Mathematics concepts.

Method

This study employed quasi-experimental design involving a 3x2x2 factorial matrix.

The target population for this study was Senior Secondary School Two (SSII) students in Edo State, Nigeria.

The sample for the study consisted of 162 SSII students selected purposively from 3 intact classes (each from 3 schools) at Benin, Ekpoma and Auchi environs of Edo State. Selection of the schools depended on the availability of professional Mathematics teachers, the distance of the schools to one another in order to remove contamination or interference effect, and willingness of school principals and teachers to cooperate and participate in the study. Another school that was used for trial testing, was again purposively selected from Benin environs but in a local government area different from the already selected schools.

The following instruments were developed and used to collect data for the study:

i. Mathematics Achievement Test (MAT). This is a test of students' achievement in Mathematics. The concepts examined were based on 26 lessons and each lesson is a topic under Trigonometry (Sine Rule, Cosine Rule and Bearing). The test items were 30 multiple-choice with four options.

ii. Students' Attitude Towards Mathematics Questionnaire (SATMQ). The instrument was originally developed and validated by Aiken (1974). It had three sections; A, B and C. Section A seeks for personal information of students (i.e school, class, age etc), while Section B contains 11 items on enjoyment of Mathematics, section C contains 10 items on value of Mathematics.

For the MAT, a Table of Specification was drawn to represent three levels of cognitive domains (Knowledge, Comprehension and Application) as well as contents covering topics taught during treatment. An initial pool of 90 items was developed. The pool was first presented to 2 experienced secondary school Mathematics teachers for face and content validity. The items were pre-tested in order to provide data for item analysis of the test. Thirty (30) items out of those that survived the analysis were selected for the final test. The 30 items were again subjected to reliability test. A split-half method was used. Pearson's Correlation Coefficient was 0.8, while the result from Spearman-Brown Correction formula was 0.89. This confirmed that the instrument was valid, internally consistent and reliable.

For SATMQ, to ascertain the reliability of the instrument, it was administered on forty students from a Senior Secondary School II (SSS II) different from the selected schools for the main study. The Cronbach Alpha formula gave the reliability coefficient value of 0.765. This confirmed that the instrument was valid, internally consistent and reliable.

Lesson notes were developed by the researchers for experimental group 1, using CESI and experimental group 2 using PT. The lesson notes for the Control group was used as developed by the class teacher. The exercise lasted for four weeks. After treatment, Post-test-test using MAT was administered to the groups to determine their ability level. After post-test, the researchers delayed for four weeks before administering the delayed post-test (retention), using the same instrument but altered to make it look as if they were different.

The data collected in this study were analyzed using appropriate descriptive and inferential statistics. Means, mean gains and standard

deviation scores are the descriptive statistics used to show magnitudes of the post-test achievement of Mathematics concepts scores according to the levels of instructional strategy, gender and attitude towards Mathematics. The seven hypotheses in the study were tested using the Analysis of Covariance (ANCOVA) test using pre-test scores as covariates. The analysis was done at the 0.05 level of significance. The accompanying Multiple Classification Analysis (MCA) was used to explain the magnitudes of the delayed post-test mean retention of Mathematics concepts scores across the different levels of instructional strategy, gender and attitude towards Mathematics while the Scheffe pair-wise comparison was the post-hoc analysis used to explain the source and direction of obtained significant effects.

Results

Table 1 Students' Post-Test & Retention of Mathematical Concepts According to Strategy

Instructional Strategy		N	Mean	S.D.	Gain	Min	Max
Combined Explicit &	Post-test	108	18.0401	4.8602	-1.8500	2	27
Systematic Instruction (CESI)	Retention		16.1901	5.4111		6	28
Peer Tutoring (PT)	Post-test	28	10.5700	2.9000		4	19
	Retention		12.0700	3.4615	1.5000	5	20
Conventional Method (CM)	Post-test	26	15.7326	2.2666		5	28
	Retention		16.1927	4.4912	0.4600	0	23
Total	Pre-test	162	16.3828	5.0700	-0.1300	2	28
	Retention		15.4838	5.2000		0	28

The result in Table 1 shows the groups' pre-test and retention mean academic achievement in Mathematics upon exposure to the instructional strategies.

Table 2 Students' Post-Test & Retention of Mathematical Concepts According to Gender

Students' Gender		N	Mean	S.D.	Gain	Min	Max
Female	Post-test	62	14.7346	4.3210		3	28
	Retention		14.7146	4.9122	-0.0200	0	27
Male	Post-test	100	17.4000	5.2443		2	27
	Retention		15.9600	5.3436	-1.4400	5	28
Total	Post-test	162	16.3868	5.0781		2	28
	Retention		15.4857	5.2093	-0.9011	0	28

The result in Table 2 shows the groups' post-test and mean retention of Mathematics concepts according to gender after exposure to the instructional strategies. According to the table, the male group recorded retention of concepts mean score of 15.96 (S.D. = 5.24, N=100) and the female group recorded retention of concepts mean score of 14.71 (S.D. = 4.32, N=62).

Table 3 Students' Post-Test & Retention of Mathematical Concepts According to Attitude

Students' Attitude		N	Mean	S.D.	Gain	Min	Max
Low	Post-test	84	15.8644	5.0223		3	27
	Retention		15.9344	4.8910	0.0700	5	28
High	Post-test	78	16.9491	5.0742		2	28
	Retention		15.0089	5.5012	-1.9402	0	28
Total	Post-test	162	16.3877	5.0734		2	28
	Retention		15.4876	5.2029	-0.9001	0	28

The result in Table 3 shows the groups mean retention of Mathematics concepts according to attitude towards Mathematics before and after exposure to the instructional strategies.

Test of hypotheses involving main and interaction effects of instructional strategy, gender and attitude towards Mathematics on students' retention of Mathematics concepts

Table 4 Summary of Analysis of Covariance of Students' Retention of Mathematics Concepts Scores According to Instructional Strategy, Gender and Attitude

Source of Variation	Sum of Squares	Df	Mean Square	F	Sig. of F
Main Effects	3115.7365	1	3115.7365	125.340	.000
Covariates (pre-test)	9.1633	1	9.1633	.369	.545
Strategy (CESI, PT & CM)	391.2233	2	195.6113	7.869	.001*
Gender	.0924	1	.0924	.004	.951
Attitude	62.4391	1	62.4391	2.515	.115
2 Way Interactions					
Strategy * Gender	52.3300	2	26.1650	1.053	.352
Strategy * Attitude	37.1190	2	18.5590	.747	.476
Gender * Attitude	23.3510	1	23.3510	.939	.334
3 Way Interactions					

Strategy * Gender * Attitude	90.1750	2	45.0870	1.814	.167
Explained	650.5760	12	54.2150	2.181	.015
Residual	3703.8690	149	24.8580		
Corrected Total	4354.4450	161			

*** indicate significant F at .05 level**
R Squared = .149 (Adjusted R Squared = .081)

The result in table 4 shows the main effect of instructional strategy (i.e. CESI, PT and CM used as strategies in the study) on the students' retention of Mathematics concepts. The result shows significant outcome ($F_{(2, 149)} = 7.869$, $P < 0.05$), implying that there exists significant difference in the post-test mean retention of mathematics concepts scores of the students exposed to the three instructional strategies. Hence, the null hypothesis eight is rejected.

Table 5 Multiple Classification Analysis of Students' Retention of Mathematics Concepts Scores According to Instructional Strategy, Gender and Attitude to Mathematics

Grand Mean = 14.972

Variable + Category Instructional Strategy	N	Unadjusted Deviation	Eta	Adjusted for Independent + Covariates	Beta
1. Combined Explicit (CESI)	108	- 0.2100		2.0200	
2. Peer Tutoring (PT)	28	- 4.9700		-1.1600	
3. Conventional Method (CM)	26	- 0.5000	.096	1.8100	.31
Gender					
1. Male	100	- 1.3700		1.4300	
2. Female	62	- 1.5300	.001	1.4700	.03
Attitude to Mathematics					
1. Low	84	- 0.6300		2.2000	
2. High	78	- 2.2600	.017	0.6900	.13
Multiple R Squared					.149
Multiple R					.386

The result in table 5 shows the magnitudes of the post-test mean retention of Mathematics concepts scores of the students exposed to the three instructional strategies. The MCA shows that with a grand mean of 14.972, the students exposed to the Combined Explicit and Systematic Instruction

(CESI) strategy recorded the highest adjusted post-test mean retention score of 16.992 (i.e. 14.972 + 2.02). The students exposed to the Conventional Method (CM), the control group, recorded the next higher adjusted post-test mean retention score of 16.782 (i.e. 14.972 + 1.81) while the students exposed to the Peer Tutoring (PT) strategy recorded the lowest adjusted post-test mean retention score of 13.812 (i.e. 14.972 - 1.16).

The result of the main effect of gender in table 4 shows no significant main effect of gender on the students' retention of Mathematics concepts ($F_{(1, 149)} = .004$, $P > 0.05$). Hence, the null hypothesis nine is not rejected.

The result of the main effect of attitude towards Mathematics in table 4 shows no significant main effect of attitude towards Mathematics on the students' retention of Mathematics concepts scores ($F_{(1, 149)} = 2.512$, $P > 0.05$). Hence, the null hypothesis ten is not rejected.

The result of the 2-way interaction effect of instructional strategy and gender in table 4 shows no significant interaction effect of instructional strategy and gender on the students' retention of Mathematics concepts scores ($F_{(2, 149)} = 1.053$, $P > 0.05$). Hence, the null hypothesis eleven is not rejected.

The result of the 2-way interaction effect of instructional strategy and attitude towards Mathematics in table 4 shows no significant interaction effect of instructional strategy and attitude towards Mathematics on the students' retention of Mathematics concepts scores ($F_{(2, 149)} = .747$, $P > 0.05$). Hence, the null hypothesis twelve is not rejected.

The result of the 2-way interaction effect of gender and attitude towards Mathematics concepts in table 4 shows no significant interaction effect of gender and attitude towards Mathematics on the students' retention of Mathematics concepts scores ($F_{(1, 149)} = .939$, $P > 0.05$). Hence, the null hypothesis thirteen is not rejected.

The result of the 3-way interaction effect of instructional strategy, gender and attitude towards Mathematics in table 4 shows no significant interaction effect of instructional strategy, gender and attitude towards Mathematics on the students' retention of Mathematics concepts scores ($F_{(2, 149)} = 1.814$, $P > 0.05$). Hence, the null hypothesis fourteen is not rejected.

Discussion

Results showed that there were significant main effect of Instructional Strategy on retention ($F_{(2,149)}= 7.869$, $P<0.05$) of Mathematics concepts taught. Comparing the adjusted post-test mean scores from Multiple Classification Analysis (MCA), it was revealed that CESI recorded the highest retention mean score of 16.992. CM recorded next to CESI with retention mean score of 16.782. PT however recorded the least with retention score of 13.812.

However, results revealed that female students recorded better post-test retention mean scores. Also, it was revealed that students with low attitude had higher post-test retention mean scores. There was neither significant main effects of gender and attitude separately nor significant interaction effects of instructional strategy, gender and attitude, on retention of Mathematics concepts.

Conclusion

From the results obtained, all the teaching strategies showed improvement in the post-test achievement scores however at different levels. Combined Explicit and Systematic Instruction (CESI) strategy was found to be the most potent in improving students' retention in mathematics. This was because concepts were taught in a procedure that encourages fluent interaction between teacher/student and student/student, using diagrams with Scaffolded formulae/techniques.

Recommendations

Based on the findings, the following recommendations were made:
Teachers should use the findings to fine-tune their teaching strategy to include CESI steps in order to get maximum attention and abstraction of formulae by students which will make them to have better performance in Mathematics tests and examinations. In the same vein, students that lay hands on this work (findings) would always try to adjust their ways of studying Mathematics to include Scaffoling as explained in CESI to easily grasp formulae which will enhance their performance.

Curriculum planners and Heads of schools should encourage and support training on how to implement CESI strategy in schools at all levels. Special workshops, in-service training, courses and seminars should be organized for teachers. Evaluation mechanisms should be established to appraise the implementation process and achievement outcomes.

Government (i.e ministries of education of the federal and state governments) should use the findings for policy formulation as regards the best teaching and learning strategy to encourage in order to improve the teaching and learning of Mathematics in schools.

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