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Comparative Effectiveness of Three Problem-Solving Instructional Strategies on Students' Heuristic Transfer in Mathematics at the Senior Secondary School Level in Nigeria

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Abstract: This study examined the comparative effects of three problem-solving instructional strategies on Secondary School two (SS II) students' heuristics transfer of mathematics skills in order to find out whether the enhanced method facilitated learning than convectional method. It also attempted to find out whether prior knowledge or gender would enhance learning. The sample of this study consisted of 450 (230 males and 220 females) which were randomly selected from ten senior secondary schools in the 6 states of south west Nigeria by using multi stage random sampling technique. Research findings revealed that those taught by heuristic transfer of mathematical skills achieved most of all and also those being taught by problem solving made more progress than those taught by conventional means. The study also shows that neither poor knowledge nor gender appeared to make any difference to gains; it was the method of instruction that mattered. Based on the finding, it was recommended that teachers all levels of Nigeria education strata should inculcate the enhanced problem solving instructional strategy in teaching and learning of mathematics.

Key words: Comparative effectiveness, insturctional strategies, mathematics, senior secondary school level

INTRODUCTION

Mathematics has been described by Bloom as a dynamic and elegant field of human creation which involves a process and a way of being what can be learned.

It is also conceived as an aspect of intelligent communication among people and a useful tool in the sciences. The growing importance of mathematics to Nigeria as a developing country cannot be overemphasized. This could account for why one of the objectives of secondary education under the National Policy on Education (1981) is to equip the students to live effectively in a modern age of science and technology.

The nation has therefore placed great emphasis on the study of mathematics and technology. The technological Development of any Nation depends largely on the teaching of mathematics and other sciences (Oladunni, 1986).

Consequently the country's educational policies and programmes are being directed towards the sciences and mathematics, which seems to be the language of science is the pivot on which these subject revolve. Despite the importance of mathematics to science technology and despite the enviable position it occupies in the community of disciplines, available evidence from literature indicated that students' achievement in the subject at public examination as well as both primary and secondary certificate examination have continued to worsen and decrease year after year (Oladunni, 1986; Oyedeji, 1992).

This alarming rate of students underachievement in mathematics at all examinations and all levels may be due to a number of factors such as; lack of enough qualified and experienced mathematics teachers, location of school, sex of teachers, type and nature of public examination items and the difficulties which teachers experienced in teaching most of the mathematics topics (especially those new topics in the new 6-3-3-4 mathematics syllabus), 6-3-3-4 is a complete educational system in Nigeria (6 years, 3 years, 3 years and years in primary, Junior secondary school, senior secondary school and University, respectively).

It appears that students' achievement in mathematics was better before the introduction of the new 6-3-3-4 syllabus but shortly after the introduction and implementation of the new 6-3-3-4 syllabus, which called for a reorganization and modification of the topics in mathematics syllabus at the secondary school, students' achievement began to fall and worsen, especially now that some advanced topics like set theory, matrices and determinants, integration and differentiation and so on, had been incorporated in the senior secondary mathematics syllabus.

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Consequently, one could tend to trace the present students under achievement in mathematics at the senior secondary level to the difficulties which the in-service (practicing) mathematics teachers experienced in teaching these topics. Many studies have been carried out to analyze the difficulties which students have in understanding mathematics (Oyedeji, 1987, Oladunni, 1986, Ilugbusi, 1988, Olarewaju, 1986) but not much has been dome to critically examine the teachers' teaching method as well as their teaching difficulties.

Although various methods like demonstration, discussion enquiry, laboratory and lecture method etc. are used in presenting information to students in school without the enhanced problem-solving instructional strategies. Hence, would these methods adequately prepare the student to solve problems effectively? This is the question to which this study addressed itself. There is therefore the need to critically examine the teacher and his method, his ability to present the necessary information. Woods (1980) defined problem solving in science and mathematics as an activity by which the best valve for an unknown is obtained, subject to a set conditions and constraints. Agbeyewa (1996) also defined heuristic-transfer in science as the ability to adapt relevant techniques from task only marginally related to the task at hand and to generate plausible strategies to solve problems that familiar.

Review of literature showed that most investigations on problem solving strategies are outside the field of mathematics coupled with the fact that there are inconsistence in the finding on students problem-solving skill some found no significant difference between the experimental and control groups other reported differently. The present study therefore is beads on the use of the WISE is an acronym for the four major steps of the problem solving instructional strategy, WISE problem solving instructional strategy developed by Wright and Williams (1986). Hence the steps of the model called WISE strategy namely; What is happening? Isolate the unknown, Substitute and Evaluate. The WISE strategy is based on a system of heuristic for easier application by students and the model is enhanced with mastery, verbal feed back and remediation in this study.

Research hypotheses: The following null hypotheses were generated and tested in this study:

HO_1: There is no significant difference between the post test mean scores in Mathematics Heuristic Transfer test (MHT) of students whop are taught using the enhanced problem-solving instructional strategy and those who are taught using conventional methods.

HO_2: There is no significant difference between post-test mean score of:

- Male and Female students.
- High, average and low prior knowledge students taught by using the enhanced problem-solving instructional strategy and those taught with the conventional method in Mathematics Heuristics Transfer test (MHT).

MATERIALS AND METHODS

This study use of a non-randomised control group pretest-post experimental design. The study sample consisted of 450 (230 males and 220 females) students which were randomly selected from ten senior secondary schools in the six states of South Western Nigeria by using Multistage Random Sampling Techniques. Generally, there were two experimental groups (a) Enhanced (b) Non-Enhanced and one control group.

The enhanced group received the lesson on the topics in the SS II mathematics syllabus; furthermore, the group received the WISE problem solving instructional strategy model that was enhanced with practice, immediate and delay feedback, teacher and student remediation. The non-enhanced group received the same lesson on the same topics and the WISE problem solving instructional strategy model.

But the control group received only the same lesson on the same topics and conventional method of solving problems by examples. Similarly, all the three groups were taught by the same teacher for six weeks.

The face, content and construct validity of the research instruments were ascertained by giving the instruments to three exerts in Test and Measurement and two expert in mathematics curriculum studies (curriculum evaluation) for critical appraisal, scrutiny and comments. The final versions were incorporated in the research instruments. The reliability indices of the instruments were obtained by using the test-retest method to be 0.71, 0.75 and 0.72, respectively.

These indices are however considered high enough for this kind of study according to Macintosh (1974) and Alonge (1989).

Furthermore, pre-treatment data were collected with Mathematics Prior Knowledge Test (MPKT) and Mathematics Heuristics Test (MHT). The MPKT was used to classify the subjects within each group to either high, average, or low mathematics MPKT was administered to the subjects. The scores in the MPKT were involved in the study, analysis of covariance was used to statically equate the subjects. Groups were also compared using the students-test. Turkey's HSD post hoc comparism test was also applied to the data in order

to determine the comparative nature of the effect of each of the treatments. The strengths of effects of the sources of between group variability were also determined.

RESULTS AND DISCUSSION

The data generated in this study were analysed accordingly and presented as shown in the Table 1.

Research question: What is the overall performance of the control, enhanced and non-enhanced groups in their pretest and post test scores in the mathematics heuristics transfer test?

Table 1 showed that the means of enhanced, non-enhanced and control groups are 13.33, 8.43 and 4.61. By implication, the enhanced group performed better than either control or non-enhanced groups in the post test. Table 1 also showed that the Z-values for the enhanced, non-enhanced and control groups are 19.92, 7.79 and -10.37, respectively. This also implies that majority of the candidates in the control group scored below the overall mean of 8.79 in the post test.

On the other hand, majority of the candidates in enhanced group scored above the overall mean of 8.79 with the mean and the Z-values of the three groups, it appears that enhanced group performed best in post-test among the three groups. It also appears that the treatment has effect on the performance of the 3 groups.

Hypothesis 1: There is no significant difference between the post test mean scores in Mathematics Heuristic Transfer Test (MHT) of students who are taught using the enhanced problem solving instructional strategy and those who are taught using the convectional methods.

The analysis on covariates in Table 2 shows that f-calculated is greater than f-table at $\alpha = 0.05$ level of significance, thus the null hypothesis is rejected, thus there was a significant difference in the academic performance of the students in post-test and pre-test. In other words, whatever the method of instruction in general, students made progress between the post-test and pre-test.

Analysis on main effects (the three groups) on Table 2 shows that f-calculated is greater than f-table thus the null hypothesis is rejected at $\alpha = 0.05$ level of significance, hence there was a significant difference between the academic performance of students who were taught using the enhanced problem solving instructional strategy and those who were taught using the convectional method and those who were taught non-enhanced method. Analysis on Explained section on Table 2 shows that f-calculated is greater than f-table, thus the null hypothesis is rejected, hence there was a significant difference between pre-test and post-test performances. In other words the methods of teaching in the study were effective. That is whatever the method of instruction in general students made progress between the pre-test and post-test.

In order to find out the source of the differential performances among the three groups, there is a need for post-hoc analysis (Turkey's Analysis).

The analysis in Table 3 shows that there was a significant difference in the academic performance between the following pairs:

- Those students taught using enhanced method and those taught using non-enhanced method in favour of enhanced.
- Those students taught using non-enhanced method and those who were not taught in favour of non-enhanced group.
- Those taught with enhanced method are those who were not taught in favour of enhanced.

Hypothesis 2: There is no significant difference between post-test mean scores of

- Male and female.
- High, average and low prior knowledge students taught solving instructional strategy and those with the convectional method in Mathematics Heuristic Transfer test (MHT).

Also, the analysis in Table 4 showed the result of analysis of variance of Mathematics Heuristic Transfer test (MHT) and Mathematics Prior Knowledge Test (MPKT) on Sex suing pretest scores as covariance. The main effects of types of problem solving instructional strategies on sex alone produced at Fc = 2.01 which is not significant at $p<0.01$ and hence there was no significant

Table 1: Descriptive statistics of pre-test and post-test scores in the mathematics heuristic transfer test

			Pre-Test		Post-Test		
Group	N	Differences	Mean (X)	SD	Mean (X)	SD	Z-Score
Control	150	3.09	2.52	1.240	4.61	1.660	-10.37
Enhanced Group (E_1)	150	10.95	2.38	0.260	13.33	1.830	19.92
Non Enhanced Group (E_2)	150	7.13	2.80	1.030	8.43	1.970	7.79
	450		2.60	0.607	8.79	0.127	

Table 2: Analysis of covariance of post-test mean scores of Mathematics Heuristic Transfer test (MHT) using pre-test scores as covariates

Sources of variation	Sun of squares	Df	Mean of sum of squares	Fc	Significant of F
Covariates	765.84	1	765.84	28.04	0.001
Main effects	2567.30	2	1526.51	55.90	0.001
Explained	2333.57	3	12223.90	44.82	0.001
Residual	10468.55	446	27.31		
Total	13802.12	449	48.87		

Table 3: Turkey's HSD pair wise comparison analysis among Enhanced (E) Non Enhanced (NE) and no treatment group

Sources of variation	Absolute differences between sample means	Vales of CD	Null hypothesis rejected
E = NE	3.9	3.05	Yes
E = C	7.72	3.05	Yes
NE = C	3.82	3.05	Yes

Table 4: Analysis of covariance of post-test scores of mathematical heuristic transfer, using pretest as covariates on sex and prior knowledge levels

Sources	Sum of Square	Df	Mean Square	Fc	Significant of F
Covariates	959.62	1	959	36.50	0.0001
Main Effects	5654.53	5	997.84	37.96	0.0001
EXPRT	4563.61	2	1948.02	74.10	0.0001
PRKNW	2668	2	634.34	24.13	0.0001
SEX	59.22	1	52.80	2.01	0.173
2-Way interaction	451.54	8	46.78	1.78	0.114
EXRT, PRKNW	353.15	4	75.39	2.87	0.0001
EXPRT, SEX	30.50	2	14.24	0.54	0.585
PRKNW, SEX	77.65	2	31.88	1.21	0.280
Explained	6093.33	20	418.61	15.92	0.0001
Residual	7903.44	428	26.29		
Total	13996.77	446	51.88		

difference between the post-test mean scores of male and females students using all three strategies in Mathematics Heuristic Transfer test (MHT).

Also from Table 4 the main effects of types of problem solving instructional strategies on the Mathematics Prior Test (MPKT) alone produced an Fc = 24.13 which is also not significant $p<0.01$, it can hence be deduced that (MPKT) is not a significant factor in problem solving Mathematics Heuristic Transfer test (MHT).

Lastly, the interaction effects of type of problem solving strategy by MPKT in Table 4 has an Fc = 2.87, which is also not significant at $p< 0.01$. Hence the effects of the 3 strategies on MHT are the same for high, average and low integrated science Prior Knowledge Test (MPKT).

The overall finding for hypothesis 2 was that, neither prior knowledge nor gender appeared to make any differences to the gains; it was the method of instruction that mattered.

Findings: Findings in this study revealed the following:

- Whatever, the method of instruction in general students made progress between the pre-test and the post-test.
- That those being taught by problem solving made progress between the pre-test and the post-test.
- That those taught by this enhanced problem solving method achieved most of all.
- Neither prior knowledge nor gender appeared to make any difference to gains; it was the method of instruction that mattered.

CONCLUSION AND RECOMMENDATIONS

The following recommendations are however made based on the findings in this study:

- Enhanced problem solving instruction strategy must be part of a comprehensive plan of a mathematics instruction.
- Curriculum planners, mathematics textbook writers and mathematics teachers and instructors should consider it necessary to adequately inculcate the enhanced problem solving instructional strategy in the teaching and learning of mathematics at all level of Nigerian Educational strategy.

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