

# Effects of three modes of personalisation on students' achievement in mathematical word problems in Nigeria

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## Abstract

*This study investigated the effects of modes of personalisation of instruction crossed with two levels each of verbal ability and cognitive style as moderator variables on the mathematical word problems achievement of 450 junior secondary Nigerian students. Personalisation was accomplished by incorporating selected information with students' personal preferences into their mathematics word problems content on either group basis, individual or self-referencing format. Students were randomly assigned to one of four treatment conditions: self-referencing, individual personalisation, group personalisation, and non-personalisation versions of an instructional programme on mathematics word problems. Results showed that treatment, verbal ability and cognitive style had significant main effects on students' achievement in mathematical word problems. Thus, students exposed to group personalisation performed significantly better than those in other groups followed by individual personalisation, self-referencing, and non-personalisation in that order. High verbal ability students performed significantly better than low verbal ability counterparts. Also, analytic cognitive style students significantly outscored their non-analytic cognitive style counterparts. There were significant two-way interactions effects of treatment and verbal ability, treatment and cognitive style, and verbal ability and cognitive style on students' achievement in mathematical word problems. These findings suggest in part that group personalisation; individual personalisation and self-referencing modes enhanced students' achievement in mathematical word problems than the non-personalisation strategy. This impact was however sensitive to the cognitive style and verbal ability of the students. These findings show the need for choosing improved strategies for mathematical word problems teaching and the recognition of the influence of verbal ability and cognitive style on students' achievement in mathematical word problems.*

**Keywords:** personalisation instruction, word problems, mathematics achievement

## **INTRODUCTION**

Many studies on personalisation of mathematical word problems have been centred on its usage as a testing method (Ku & Sullivan, 2002; Reninger, Ewen & Lasher, 2002) involving comparisons of personalised and non-personalised problems on assessments. It is evident that students are no more successful answering word problems when the word problems are personalised and reflect their areas of interest than when the problems are taken verbatim from mathematics textbook (Bates & Wiest, 2004). In contrast, Reninger et al (2002) assert that personalised contexts based on individual interests can have a differential effect on students since these contexts encourage students to connect with the meaning of problems.

As an instructional practice, personalisation has received scant attention and few studies have focused on the potentially differential impact of the modes of personalisation. A possible explanation for this phenomenon may be the time constraint in personalising individual or group instructional programme on mathematical word problems. By mathematics word problems, we mean any mathematics exercise expressed as a hypothetical situation explained in words. The importance of mathematics word problems to students cannot be over-emphasised. Mathematics word problems are frequently used to determine students' ability to decipher vital information and also to estimate students' ability to use their analytical and mathematics skills to solve problems. Mathematics word problems are used to relate mathematics to real life problem situations, motivate students to understand the importance of mathematics concepts and help students to develop their creative, critical and problem solving abilities.

However, the present study was designed to investigate the main and interaction effects if any of three modes of personalisation, verbal ability and cognitive style on the mathematics word problems achievement of students in junior secondary year one. By main effect, we mean the effect of an independent variable on a dependent variable averaging across the levels of any other independent variables. An interaction effect is a change in the simple main effect of one variable over levels of the second variable. Specifically, it was hypothesised that there would be no significant main effect of (i) treatment, (ii) verbal ability, and (iii) cognitive style on students' mathematics word problems achievement. Also, there would be no significant interaction effect of (i) treatment and verbal ability, (ii) treatment and cognitive style, (iii) verbal ability and cognitive style, and (iv) treatment, verbal ability and cognitive style on students' mathematics word problems achievement.

## **Modes of Personalisation**

Three modes of personalisation have been identified- self-referencing, individual and group and recent investigations have revealed equivocal findings about the efficacy of each mode on the mathematical word problems achievement of primary and secondary school students. In particular, although the results of some studies have shown that individual personalisation, group personalisation and self-referencing when viewed singly positively impacts student achievement (d'Ailly & Simpson, 1997; Ku & Sullivan, 2002; Hart, 1996), the results of other studies have revealed that personalisation irrespective of its mode shows no significant improvement in student achievement (Wright & Wright, 1986).

Self-referencing involves replacing the character names of standard mathematics word problems with the word you. d'Ailly et al (1997) noted that “when a you word was involved in the problem, children asked for fewer repeats for the problems and could solve the problems in a shorter amount of time and with a higher accuracy”(p.566).

Individual personalisation refers to tailoring the domain context of instruction to individual rather than whole-class common interests and preferences. Lopez and Sullivan (1992) remarked that individual personalised word problems might be more meaningful in general and make contexts more concrete and more familiar.

Group personalisation connotes tailoring the domain context of instruction to dominant interest and preferences of a group of students. While group personalisation is effective in learning word problems (Lopez & Sullivan, 1992) it is easier and less time-consuming to implement than individual personalisation, especially in situations where a computer is not available for each student (Ku & Sullivan, 2000).

## **Mathematics Word Problems**

Word problem refers to a problem stated using grammatical sentences rather than mathematical symbols. Mathematical word problems have been targeted for personalisation and the content for the study was based on algebraic and arithmetic concepts in mathematics. This is because the mathematical concepts are more amenable to word problems personalisation. Word problems in mathematics have been researched and found difficult by students (Onabanjo, 2004) and researchers (Akinsola & Tella, 2001; Bates & Wiest, 2004) have proffered reasons for the difficulties students experienced. They include: lack of reading ability, irrelevance of word

problems to students' lives, lack of motivation to solve word problems and limited experience with word problems.

Ameliorating the difficulties may be to provide rich, meaningful contexts that situate both problems and its associated mathematical operations in familiar context. Such approach may make instruction more personally relevant to the students. Ku and Sullivan (2000) reiterated this and in particular suggested the adoption of personalisation strategy. The mathematics word problems used in this study were taken directly from a section of the junior secondary year one mathematics textbook that the subjects had not yet studied. The word problems were personalised on a self-referencing, group and individual formats.

### **Learners' Variables**

The influence of learners' variables such as gender, academic ability, reading ability, home background, verbal ability, and cognitive style among others in mathematics education (Akinsola, 1994; Balogun, 1993; Oladele, 1997; Oyedeji, 1996; Olaleye, 1997) has been the source of a substantial amount of empirical research in the last decade particularly in Nigeria. But only in recent years have researchers begun to explore the influence of verbal ability and cognitive style on mathematics achievement. In fact, researchers have documented that students' verbal ability significantly influence their performance on standardized achievement tests (Fakeye, 2006; Maduabuchi, 2002). However, despite the frequently reported findings about the influence of learner variables in earlier research on personalization (Bates & Wiest, 2004; Ku & Sullivan, 2000; Lopez, 1989; Murphy & Ross, 1990) the influence of verbal ability and cognitive style on the presumed effects of personalisation on students' mathematics word problems achievement was ignored in most previous studies.

Verbal ability refers to an individual's intelligence or language development level and his/ her ability to do abstract reasoning (Nwosu, 2002; Odiaka, 2002). Cognitive style is seen as an individual's particular way of processing and representing information. Studies on cognitive style show that the analytic cognitive style students are very critical in their reasoning and are able to distinguish figures as discrete from their background as opposed to the non-analytic students who do experience events in an undifferentiated way (Dorothy, 1991; Ige, 2001; Riding & Al-Salih, 2000). Some scholars found students' cognitive style to significantly relate to high mathematics achievement in favour of analytical cognitive style students (Vaidya & Chansky, 1980; Roberge & Flexer, 1983) while some were in favour of non-analytical cognitive style

students (MacGregor, Shapiro & Niemiec, 1988). Others like Scott (1977) did not see any relationship between students' cognitive style most especially analytical style and achievement in mathematics. In a study, on effects of a computer-augmented learning environment on math achievement for students with differing cognitive style, MacGregor, Shapiro and Niemiec (1988) found a significant treatment by cognitive style interaction. Non-analytical cognitive style students exhibited greater mathematics achievement in a computer-augmented environment, whereas students with indiscriminate cognitive style demonstrated greater achievement in a traditional learning environment. The results supported the hypothesis that learning environments differentially affect students with dissimilar cognitive style. In respect of verbal ability and academic achievement, high verbal ability students tend to achieve better than low verbal ability students (Aimunmondion, 2008; Nwosu, 2002; Odiaka, 2002). Jiboku (1998) did not see any relationship between verbal ability and academic achievement.

These inconclusive results about the learners' variables of cognitive style and verbal ability and mathematics achievement in previous studies warrant further scrutiny. Hence, the need to ascertain the effect of cognitive style and verbal ability as it relates to personalisation of instruction on students' achievement in mathematics word problems.

## **METHODOLOGY**

### **Research Design**

This study adopted a pretest- posttest control group design in a quasi- experimental setting in which the treatment (at four levels) was crossed with verbal ability at two levels and cognitive style at two levels. Thus, a  $4 \times 2 \times 2$  factorial matrix was involved. The design is schematized in Figure 1 below.

### **Figure 1. Design Schema**

Experimental group 1:  $O_1 X_1 O_2$

Experimental group 2:  $O_1 X_2 O_2$

Experimental group 3:  $O_1 X_3 O_2$

Control group:  $O_1 X_4 O_2$ ,

where  $O_1$  represents pre-test scores,  $O_2$  represents post-test scores while  $X_1, X_2, X_3$  and  $X_4$  represent treatments in experimental groups and control group respectively. Specifically,

$X_1$  = Individual personalisation strategy

$X_2$  = Group personalisation strategy

$X_3$  = Self-referencing personalisation strategy

$X_4$  = Non- personalisation strategy

### **Participants**

The sample consisted of 450 junior secondary year one Nigerian students (240 boys and 240 girls), of varied verbal ability levels (220 ranked high and 230 low) and cognitive style levels (218 analytic and 232 non-analytic). The mean age of participants was 12.32 years (SD = 2.751). Simple random sampling technique by means of ballot was used to select two intact classes each of at most 30 students per class from eight equivalent co- educational secondary schools that were distantly located from one another within the city of Ibadan, Nigeria. The eight schools were purposively selected in order to minimize experimental contamination.

### **Instrumentation**

#### **Personal Interest Inventory (PII)**

This inventory developed by the researchers was used to determine the personal background and interests of the participants. The inventory included 18 items such as students' name, favourite store, places, foods, friends, sports, game, vehicles and so forth and was in open- ended form so that students wrote in their answer for each item. The inventory was face validated in terms of language clarity to the target audience.

#### **Mathematics Word Problems Achievement Test (MAWPAT)**

This is a 16 item constructed- response achievement test comprising two- step mathematics word problems involving arithmetic and algebraic concepts. The test included 4 problems covering

each of the 4 basic arithmetic operations in a mix, all in non-personalised form. The table of specification for the construction of MAWPAT is presented in Table 1 below. This ensured that the MAWPAT contained task at the various cognitive levels. Each answer was scored as correct or incorrect only. The level of achievement of a student was taken to be directly proportional to the student's total test score. An example of the test item is given below.

Ade has 10 oranges in a basket. If there are 3 baskets in all, how many oranges are in the baskets?

**Table 1. Table of Specification for MAWPAT**

Topics	Knowledge	Understanding	Application	Total
Algebraic expressions	7,14,6	2,4,10	1,3,11	9
Arithmetic expressions	8,9	12,15	5,13,16	7
Total	5	5	6	16

Source: Authors' field work

The MAWPAT was given to three mathematics teachers in secondary schools for scrutiny to ascertain its content validity. It was trial tested on 40 junior secondary year one students in two different schools in Ibadan metropolis. Kuder-Richardson's formula 20 was used to determine the reliability coefficient and the value obtained was 0.86. Since the reliability value is high, this shows precision and that the MAWPAT can be used in subsequent research of this nature. The discriminating indices for each of the 16 items in the MAWPAT as well as the average difficulty levels were computed. The average difficulty index obtained was 0.46 which shows that the instrument was neither too difficult nor too simple. The MAWPAT was used as pretest and posttest.

### **Australian Council for Educational Research Test (ACER)**

The Verbal Ability Test (VAT) of the ACER, which had undergone several modifications and revalidations for Nigerian use (Abimbade, 1987; Aimunmondion, 2008; Fakeye, 2006; Maduabuchi, 2002; Olaboopo, 1999; Obemeata, 1974), was used as the measure for determining

the verbal ability level of the participants. The participants were categorized as low or high verbal ability based on their scores on the VAT. The VAT was revalidated on 40 junior secondary year one students in two different schools in Ibadan metropolis through test- retest method leaving an interval of two weeks between the first and second administration. The students used in this case were not part of the participants in the main study. Data collected from the first and second administration were correlated using the Pearson Product Moment Correlation and a reliability coefficient of 0.86 was obtained.

### **Cognitive Style Test (CST).**

This is an adapted version of the Sigel cognitive style test, which consists of twenty triads of familiar pictures. This instrument, which had been modified and validated for Nigerian use (Onyejiaku, 1980; Adeyemi, 1987; Aghadiuno, 1992; Ige, 2001; Olajengbesi, 2006), was used to classify participants into analytic or non- analytic based on the reasons they gave for their choices of two items that go together in each triad. The statements made by the student regarding the way he/she perceives the pictures and classifies any two together could be categorized into three namely:

(a) **Analytic Descriptive (AD)** – Students here place together objects based on their shared or common characteristics, which are directly discernible. Example, in a card containing a man, a bed and a chair, participants here place together bed and chair because ‘they are made of wood’.

(b) **Categorical Inferential (CI)** – Participants here, place together objects on the basis of super ordinate features, which are not directly discernible (abstract), but are inferred. Example, participants here will place a bed and chair together because ‘they are for relaxation’

(c) **Relational Contextual (RC)** - Participants here, place together objects or events on the basis of features establishing a relational link between them. Example, participants here will place together, the man and the bed or the man and the chair on the ground that, ‘the man can sit on the chair’ or ‘the man can sleep on the bed’.

In this study, analytic style participants were those who scored above the median on AD and CI responses and below the median on RC responses. Non-analytic style participants were those who scored above the median on RC responses and below the median on AD and CI responses.



The CST was revalidated on 40 junior secondary year one students in two different schools in Ibadan metropolis through test- retest method leaving an interval of two weeks between the first and second administration. The students used in this case were not part of the participants in the main study. Data collected from the first and second administration were correlated using the Pearson Product Moment Correlation and a reliability coefficient of 0.72 was obtained.

### **Instructional Programme on Mathematics Word Problems (IPMWP)**

Four parallel versions of an instructional programme on mathematics word problems were developed in print form in English. All the versions were paper- based because, as in the case generally in Nigeria, not enough computers were available at the schools at the time to deliver the instruction by computer. The non- personalised version was written first and provided only minimal, non- meaningful contextual information as obtained in the students' mathematics textbooks. The other three versions provided familiar, relevant problem contexts but at varying degree of personalisation. The group personalised version was written by incorporating whole- class most popular referents (places, finds, sports, etc) from the students' personal interest inventory. This was accomplished by calculating the frequency choice on any of the inventory items and percentage found. In the individual personalised version, each word problem was tailored to each individual student background and interests as supplied by the student personal interest inventory. The self- referencing version was written by replacing the character names of problems taken from standard mathematics textbooks with the word you. While the four versions required the same computational skills and numbers, the problem contexts differed. Also, the self- referencing, individual and group personalisation versions were based on the Instructional Development Model developed by the National Special Media Institutes in the United States in their development and implementation. The design model adapted from Gustafson (1995) has three phases: define, develop and evaluate. The instructional programme also covered procedures for solving word problems. A Polya's (1945) four- part strategy: understanding the problem, developing a plan, carrying out the plan, and looking back was incorporated into the four versions.

**Example:** A Mazda 626 car filled with Milo travels 132km from Lagos in  $1\frac{1}{4}$  hours. Calculate the speed of the car?

**Step1** Understanding the problem: in this step the solver is expected to find the unknown, gather the data and separate the data into parts.

- (a) The car travels a distance of 132km and uses  $1\frac{1}{4}$  hours
- (b) Find the relationship among speed, distance and time and the speed of the car.

**Step 2** Develop a plan:

- (a) Let the speed, distance and time be S,D and T respectively
- (b) The relationship among S, D and T is defined as  $S=D/T$
- (c) Determine the value of S

**Step3** Carrying out the plan: In the ‘solve’ step, the students will perform the mathematical computations necessary to get an answer.

$$\begin{aligned} S &= D/T \\ &= 132\text{km}/ 1\frac{1}{4} \text{ h} \\ &= (132\text{km} \times 4)/5\text{h} \\ &= 105.6\text{km/h} \end{aligned}$$

**Step 4** Looking back: In this step, the solver is encouraged to examine the solution process, check the result, think of other methods to solve the problem and decide if the strategy could be adopted for other problems.

Instruction on the strategy for solving the word problems contained the rule and its application with appropriate examples and practice problem were provided. Answers to all problems were provided at the end of the instructional programme to enable self- checking. Each version contained a review of the practice problems in line with the procedures for solving the problems.

## **Procedure**

The study lasted for four weeks and was carried out in sixteen classrooms with a teacher and a research assistant in each class. In the first week, students were made to respond to four instruments i.e. Personal Interest Inventory (PII), Mathematics Word Problems Achievement Test (MAWPAT) as pretest, Verbal Ability Test (VAT), and Cognitive Style Test (CST), second

week was used to develop the personalised versions of the instructional programme on mathematics word problems using the students' Personal Interest Inventory. On the first day of third week, schools were randomly assigned to one of four treatment conditions: self-referencing, individual personalisation, group personalisation and non- personalisation and participants were instructed about the study's purpose, procedures and lesson materials. On the second day the treatment commenced and participants in each intact class studied independently their corresponding version materials for four consecutive days during a single 40- minutes class period. During the lesson, teachers and research assistants acted as a medium for management and control. The last week was used for administration of MAWPAT as posttest. In order to prevent halo effects, which could result from familiarity with posttest, four counter-balanced versions of the MAWPAT were randomly administered. All the participants that studied individual personalised version were classified as Experimental group I (n =113), those that studied group personalised version, Experimental group II (n =115) while those participants that studied self-referencing version were regarded as Experimental group III (n =110). The Control group (n =112) studied the non- personalised version.

### **Data Analysis**

The posttest achievement scores were subjected to analysis of covariance (ANCOVA) using pretest achievement scores as covariates. The ANCOVA reduces experimental error by statistical rather than by experimental procedure (Coolican, 1994). Scheffe post hoc measure was also used, and the interaction effect was explained using graphical illustrations.

## **RESULTS**

### **Hypothesis 1**

There is no significant main effect of (i) treatment, (ii) verbal ability, and (iii) cognitive style on students' mathematical word problems achievement. This hypothesis was tested using a 4x 2x 2 analysis of covariance. The results of this analysis are given in table 2.

**Table 2: Summary of 4x 2x 2 Analysis of Covariance (ANCOVA) of Students' Post Test Achievement Score in Mathematical Word Problems by Treatment, Verbal Ability and Cognitive Style**

Source of variation	Sum of squares	Df	Mean squares	F	Sig (p)
Covariates	441.600	1	441.600	34.683	.000
Main Effects	6354.318	5	1270.8636	90.871	.000
Treatment	3989.348	3	1329.7827	118.621	.000*
Verbal ability	132.681	1	132.681	18.364	.000*
Cognitive style	354.781	1	354.781	30.871	.000*
2- way Interactions (combined)	307.782	7	43.969	4.687	.019
Treatment × Verbal Ability (VA)	215.681	3	71.89	6.891	.003*
Treatment × Cognitive Style (CS)	190.380	3	63.46	5.721	.012*
Verbal Ability × Cognitive Style	94.687	1	94.687	8.902	.013*
3- Way Interaction					
Treatment × VA × CS	16.381	2	8.1905	.542	.783
Model	7120.081	15	474.672	38.673	.000
Residual	4234.281	433	9.778		
Total	11354.362	448	25.344		

\*Significant at  $p < 0.05$

Table 2 showed that there was a significant difference among the treatment groups (Experimental groups I, II, III and control group) ( $F_{(3, 433)} = 118.621, p < .05$ ); verbal ability levels ( $F_{(1, 433)} = 18.364; p < .05$ ), and cognitive style levels ( $F_{(1, 433)} = 30.871; p < .05$ ) in the post achievement observations. Thus, there was significant main effect of (i) treatment, (ii) verbal ability, and (iii) cognitive style on students' achievement in mathematical word problems. Therefore, the result justified the rejection of the above null hypothesis. Table 3 below provided some indications of the performances of various groups and levels using Multiple Classification Analysis (MCA).

**Table 3: Multiple Classification Analysis (MCA) on Posttest Achievement Score in Mathematical Word Problems by Treatment, Verbal Ability and Cognitive Style**

Grand mean= 13.22

Variable	N	Unadjusted Deviation	Eta	Adjusted Deviation	Beta
Treatment: Group personalization	115	5.84		5.32	
Individual personalisation	113	3.99		4.14	
Self-referencing personalisation	110	-2.34	.683	-2.55	.644
Control	112	-4.87		-4.52	
Verbal: Low	230	-2.38	.321	-.81	.153
High	220	2.74		.86	
Cognitive: Analytic	218	-2.58		-2.36	
Non- Analytic	232	2.83	.360	2.08	.201

$R = .792$

$R^2 = .627$

The students exposed to Group personalisation strategy had the highest mean score ( $\bar{x} = 18.54$ ), followed by students exposed to Individual personalisation strategy ( $\bar{x} = 17.36$ ), followed by those exposed to self-referencing strategy ( $\bar{x} = 10.67$ ), and those exposed to non-personalised strategy ( $\bar{x} = 8.7$ ). This implies that Group personalisation strategy is most effective in learning of mathematical word problems, followed by the use of Individual personalisation strategy, then self-referencing strategy. While table 3 further revealed that treatment accounted for about 41.5% ( $0.644^2$ ) of the variation in students' achievement in mathematical word problems, verbal ability and cognitive style accounted for 2.34% ( $0.153^2$ ) and 4.04% ( $0.201^2$ ) respectively of the variation in students' achievement in mathematical word problems. To determine the actual source of the observed significant differences as indicated in the ANCOVA table and to test for significant differences between pairs of means of the different treatment groups appearing in table 3, Scheffe post-hoc analysis was carried out.

**Table 4: Scheffe Post-hoc Test on Posttest Achievement in Mathematics Word Problems**

<b>Treatment</b>	<b>Mean</b>	<b>Group Personal</b>	<b>Individual Personal</b>	<b>Self-personal</b>	<b>Non-personal</b>
Group personalization	18.54			*	*
Individual Personalisation	17.36			*	*
Self- referencing	10.67	*	*		*
Non-personalisation	8.7	*	*	*	

\*Pairs of means that are significantly different at ( $p < .05$ )

The results of the analyses showed that the significant main effect of treatment recorded in this study was as a result of significant differences ( $p < .05$ ) in the mean performance of students exposed to (i) group personalisation and self- referencing strategies, (ii) group personalisation and non- personalisation strategies, (iii) individual personalisation and self- referencing strategies, (iv) individual personalisation and non- personalisation strategies, and (v) self- referencing and non- personalisation strategies.

Thus, while group and individual personalisation strategies are almost the same in their effectiveness on students' achievement in mathematical word problems, the two strategies indicated their effectiveness in raising students' achievement in mathematics word problems over either self- referencing strategy or non- personalisation strategy. The self- referencing strategy is more effective than the non- personalised strategy.

**Hypothesis 2**

There is no significant interaction effect of (i) treatment and verbal ability (ii) treatment and cognitive style and (iii) verbal ability and cognitive style on students' mathematical word problems achievement.

The results of the analysis of covariance in table 2 showed that there were significant ( $p < .05$ ) two-way interactions of treatment and verbal ability, treatment and cognitive style, and verbal ability and cognitive style in achievement in mathematical word problems. Therefore, the above null hypothesis was rejected.

Further analyses using line graph provide illustration on the nature of the significant interactions.

**Fig. 1: Interaction Effect of Treatment and Verbal Ability**

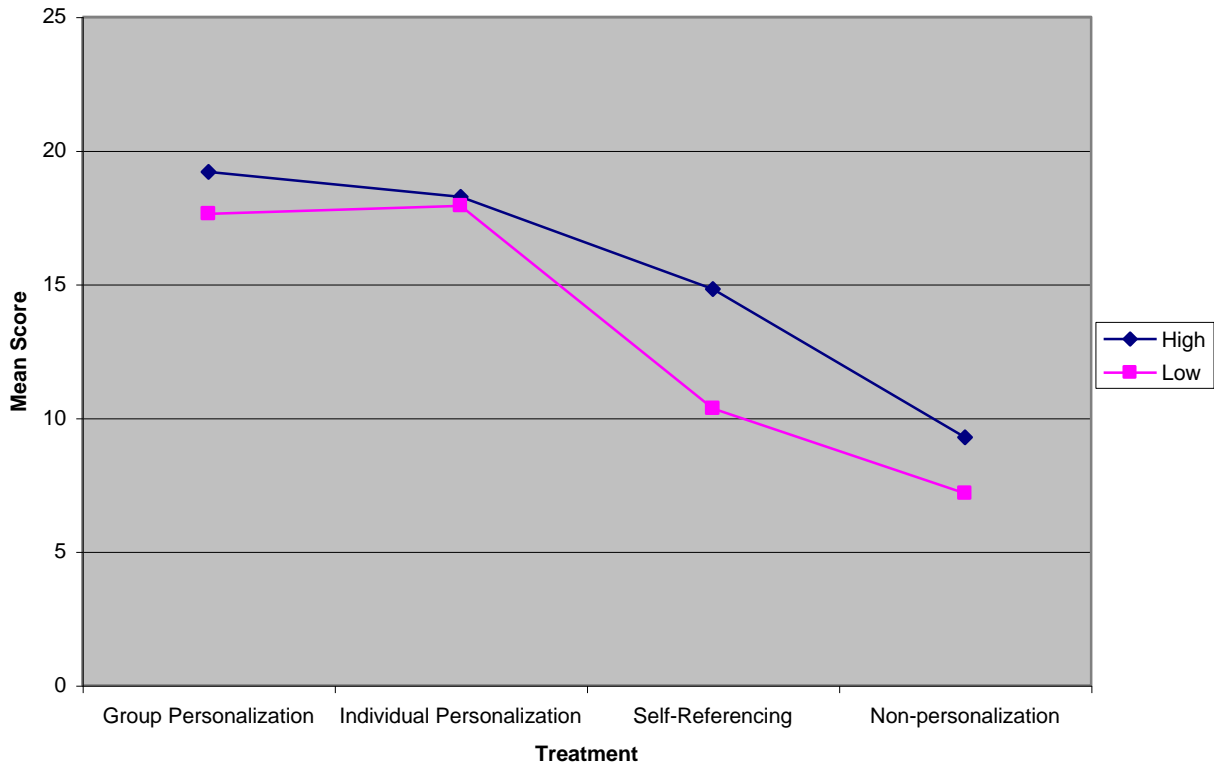


Figure 1 showed that students with high verbal ability performed better than students with low verbal ability in all the treatment conditions. However, students with high verbal ability gained more in mathematical word problems achievement under self- referencing treatment than students with low verbal ability. Figure 1 also showed that the individual personalisation group recorded the least variation between high and low verbal ability student achievement scores.

**Fig. 2: Interaction Effect of Treatment and Cognitive Style**

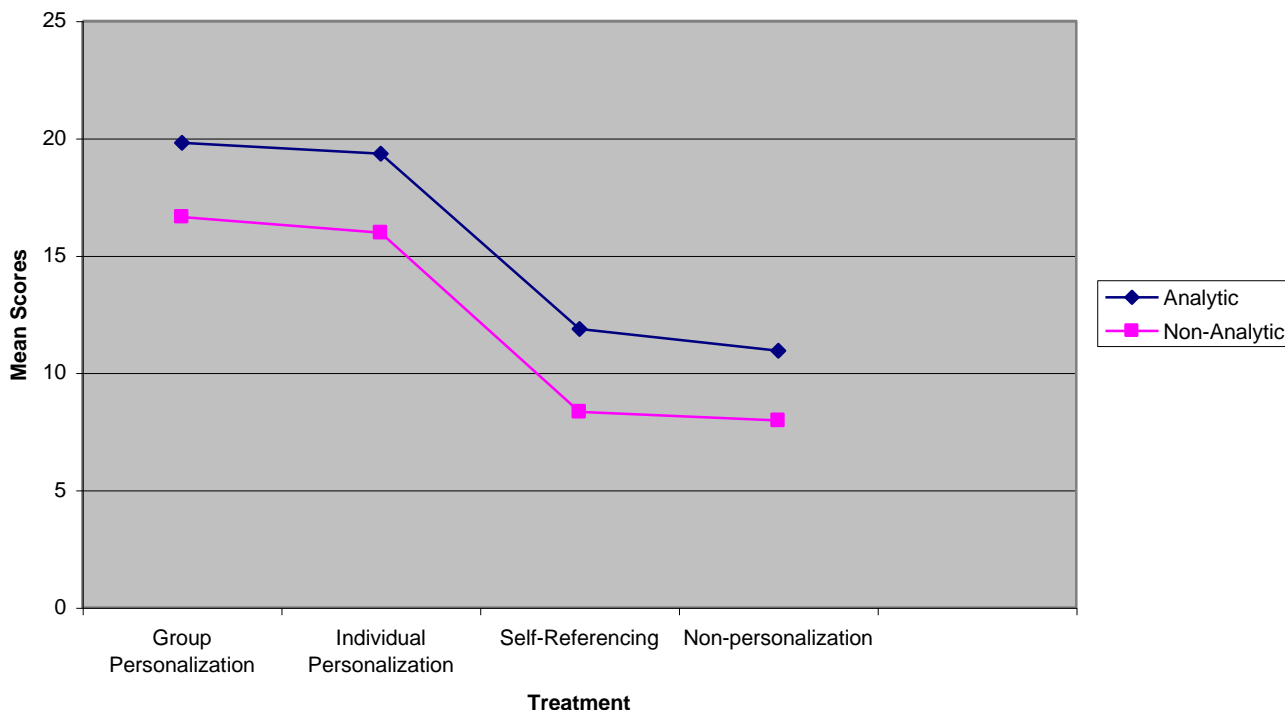
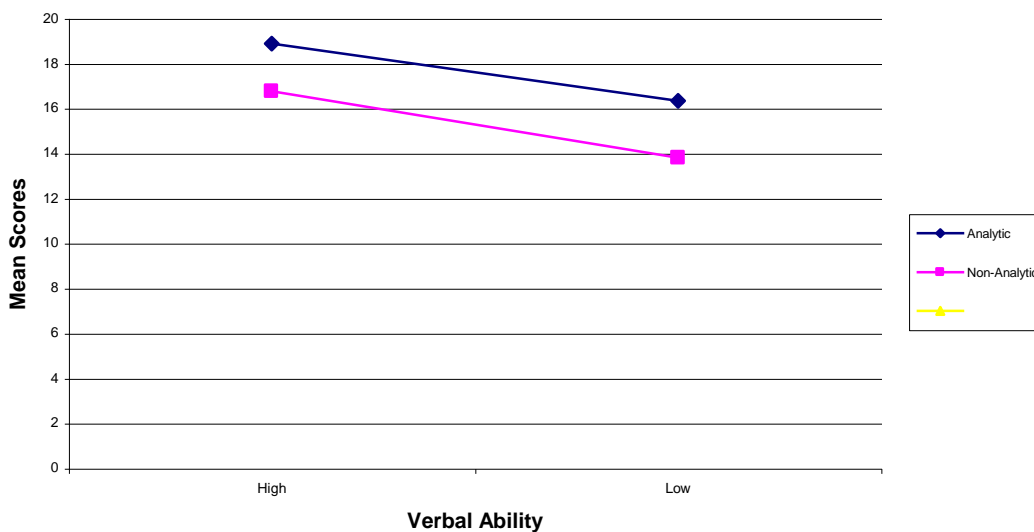


Figure 2 indicated that students with analytic cognitive style performed better than students with non-analytic cognitive style in all treatment conditions.

**Fig 3: Interaction Effect of Verbal Ability and Cognitive Style**



Also, figure 3 showed that analytic cognitive style (high and low verbal ability) students performed better than non-analytic cognitive style (high and low verbal ability) students in



mathematical word problems achievement. However, students with high verbal ability of analytic cognitive style gained more in mathematical word problems achievement than those with low verbal ability of non- analytic cognitive style.

### **Hypothesis 3**

There is no significant interaction effect of treatment, verbal ability and cognitive style on students' mathematical word problems achievement.

The results of the analysis of covariance in table 2 indicated that there was no significant ( $p > .05$ ) three- way interaction of treatment, verbal ability and cognitive style on achievement in mathematical word problems. Therefore, the null hypothesis was not rejected.

### **DISCUSSION**

The first hypothesis of this study predicted that there is no significant main effect of (i) treatment, (ii) verbal ability, and (iii) cognitive style on students' mathematical word problems achievement. This hypothesis was not supported by the results of this study as shown in table 2.

The better performance of the learning strategy groups of group personalisation, individual personalisation, and self- referencing over the non- personalised strategy group may have been due to students' greater familiarity with the personalised content. It is noted that familiarity with the problem content reduces students' cognitive load in understanding and processing the elements of the problem and enhances capability to solve problems with less difficulty. This possibility was recognised by other researchers (Ku & Sullivan, 2002; d'Ailly & Simpson, 1997). All of these previous studies indicated support for personalisation strategy. Teachers of mathematics in secondary schools should bear in mind that infusing students' personal interest into the problem content may not only increase familiarity with the problem content but also increase perseverance and motivation to solve the problem. The present study would indicate that personalised treatments have adequately addressed at least three reasons commonly offered for students' inability to solve word problems. The reasons are limited student experience with word problem (Bailey, 2002), lack of motivation to solve the word problem (Hart, 1996), and irrelevance of word problems to students' lives (Ensign, 1997).

Another reason for the presence of significant personalisation effect on students' achievement in mathematical word problems may be due to the presence of vicarious emotions and cognitive representations in the learning tasks. By adapting the domain context of

instruction in word problem to containing personal referents, learners can gain significant personal information about their capabilities with respect to the strategies enacted to engage the problem. In this study, students in the three experimental groups were able to picture personal referents in the problem and this experience may have motivated them to gain efficacy and using the strategies for solving the problems.

The nature of personalisation may have contributed to the results of this study. By allowing learners to have control over the personal referents of instruction such as character names in a word problem setting may help them envision being in the problem context. This may have assisted the learners in this study to accommodate new information with existing knowledge structures thereby attending to the personal meaning and relevance of the context to their everyday life experience. This possibility was recognised by other researchers (Davis-Dorsey, 1989; Ross, 1983; Ross & Anand, 1987).

The age of the students may have also contributed to the significant personalisation effect recorded in this study. Studies have indicated that older pupils in elementary school and at higher-grade level benefited greatly from personalisation of instruction than younger pupils (Renninger et al, 2002; Ku & Sullivan, 2002). The present study dealt with junior secondary one students and found significant personalisation effect on their achievement in mathematical word problems. This result is at variance with that of Bates and Wiest (2004) who concluded that personalisation might not be beneficial to younger children in elementary schools. The implication of the result of the present study is that students in junior secondary one may benefit more from personalisation of mathematics instruction, having more developed schemata for processing information in a real-world context.

The significant main effect of verbal ability on achievement in mathematical word problems recorded in this study lends support to the assertion that regardless of the quality of learning strategies used by the teacher, verbal ability will have an effect on students' achievement. This result is consistent with the findings of many previous studies on verbal ability (Aimunmondion, 2008; Nwosu, 2002; Odiaka, 2002) but at variance with some other (Jiboku, 1998). At the secondary school level it is assumed that students are instructed verbally and the extent to which a student succeeds in learning mathematics will depend on his or her verbal ability. The implication of this finding is that students should be helped to learn more about everything, if we want to improve their word problem solving capacity and this can be

achieved by exposing them early enough to reading diverse mathematics materials both at home and at school. Mathematics as a language required word power acquisition.

The presence of cognitive style effect on mathematics word problems achievement in this study is consistent with the results of other researchers (Adiatu, 2004; Agina-Obu, 1991; Onyejiaku, 1980; Roberge & Flexer, 1983; Vaidya & Chansky, 1980) but at variance with that of Ige (2001) and Scott (1977). Students' cognitive style was found to have contributed significantly ( $p < .05$ ) to the variation in their scores in mathematical word problems. Hence analytic cognitive style students outscored their non-analytic cognitive style counterparts in mathematical word problems. This may have been due to the nature and effectiveness of the analytic cognitive style students over their non-analytic cognitive style counterparts in problem solving. Also, the analytic cognitive style students are believed to possess better strategies for processing information (Dorothy, 1991) than their non-analytic counterparts who are regarded as being passive and ineffective in problem solving. The analytic cognitive style students may have benefited so much from the treatment, which not only gave explicit instruction in personalisation but also gave them individual prescription support in solving word problems. This observation agrees with the views of Messick (1984) and Witkin, Moore, Goodenough and Cox (1977) that analytic cognitive style students tend to learn more effectively under conditions of intrinsic motivation (e.g. self study) and are less influenced by social reinforcement which the treatment made available to them unlike their non-analytic counterparts who tend to learn more under conditions of external motivation (e.g. group study) and are influenced more by social reinforcement. Also, the analytic cognitive style students prefer solitary impersonal situations in which they are concerned with ideas and abstract principles characteristic of science/mathematics oriented studies whereas the non-analytic cognitive style students prefer interpersonal situations in which they are involved with others, they are more interested and get along with other persons.

However, taking the independent and moderating variables (treatment, verbal ability and cognitive style) together, they all accounted for 62.7% of the variation in students' achievement in mathematical word problem at the 0.05 level of significance.

The second hypothesis of this study predicted that there is no significant interaction effect of (i) treatment and verbal ability (ii) treatment and cognitive style and (iii) verbal ability and cognitive style on students' achievement in mathematical word problems. This hypothesis was not supported by the results of this study as shown in table 2. The significant ( $p < .05$ )

interaction effect of (i) treatment and verbal ability and (ii) treatment and cognitive style on students' achievement in mathematical word problems confirms the assertion of researchers (Olaboopo, 1999; Adiatu, 2002; Maduabuchi, 2002; Fakeye, 2006; Olajengbesi, 2006) that each personal variable of verbal ability and cognitive style separately interacts with instruction to produce results. This result implies that the personalisation modes are not only sensitive to verbal ability but also to students' cognitive style. With respect to cognitive style, analytic more than non-analytic students are very critical in their reasoning and are able to distinguish figures as discrete from their background and this may have enhanced their achievement in mathematics word problem. The low variation between high and low verbal ability student achievement scores in the individual personalisation group may be that this mode of personalisation brings about an increase in motivation for learning in both high and low verbal ability students with high verbal ability students experiencing a comparable motivational level with low verbal ability students. Teachers of mathematics in secondary schools should keep this result in mind when using personalisation strategy to effect achievement in students. The significant ( $p < .05$ ) interaction effect of verbal ability and cognitive style on students' achievement in mathematical word problems implies that the verbal ability and cognitive style of a student foster his or her achievement in mathematical word problems. Thus, with improved level of verbal ability and cognitive style a student would perform better in mathematical word problems.

The last hypothesis of the study predicted that there is no significant interaction effect of treatment, verbal ability and cognitive style on students' achievement in mathematical word problems. This hypothesis was supported by the result of this study (table 2). The insignificant ( $p > .05$ ) 3-way interaction effect indicated that treatment, verbal ability and cognitive style do not mutually influence achievement in mathematical word problems to produce a joint effect. This result can be explained in that achievement in mathematical word problems of students with different verbal ability levels and of different cognitive styles may tend to be consistent under any instructional strategy irrespective of whether the students exhibit high or low verbal ability level or whether they are of analytic or non-analytic cognitive style.

However, a limiting factor in this study may be that personalisation of instruction can only be used to extend students' achievement in mathematics word problems. Non-word problems in mathematics are not amenable to personalisation study. We anticipate that personalisation irrespective of its mode will be studied in relation to other proven strategies in

word problems e.g. problem solving to see whether personalisation will still give a desirable result.

## **CONCLUSION**

Based on the results of this study, it can be concluded that personalisation of instruction enhances students learning in mathematics word problems better than the non-personalisation type.

In the light of the findings of this study, the following recommendations are made: Personalisation of instruction irrespective of its modes should be adopted as viable strategy for improving mathematics word problems instruction and achievement. Teachers of mathematics should endeavour to match personalisation strategy with manner in which students receive and process information. Personalisation modes such as individual personalisation that reduce verbal ability difference in mathematics word problems achievement as recorded in this study should be used as a basis for individualising instruction for high and low verbal ability students. Personalisation should be used to break the monotony of word problems containing abstract and non-meaningful contexts, unfamiliar and irrelevant situation. Teachers of mathematics at all levels in Nigeria and else where should learn the interest of their students and incorporate these interests into their mathematics problems and instruction. The content of new mathematics textbooks in Nigeria and else where should attend carefully to contexts as well as the content of mathematics word problems in order to make the problems more personal and interesting to students. Personalisation of instruction will seem to provide the pre-service teachers with a basis of being flexible in their teaching of word problems in mathematics. Prospective teachers on pre-service teaching programmes should be trained on the use of personalisation of instruction to deal with word problems in mathematics since these teachers will have the most important mission in the classrooms of the future, and will guide us, the teacher educators.

## REFERENCES

- Abimbade, A. (1987) *Effects of the use of Electronic Calculator on Outcomes of Mathematics Instruction*. Unpublished Ph.D. Thesis, Department of Teacher Education, University of Ibadan.
- Adeyemi M.A. (1987) *Effects of Cognitive Styles and Two Instructional Modes on the Achievement of Secondary School Students in Biology*. Unpublished Ph.D. Thesis, Department of Teacher Education, University of Ibadan.
- Adiatu, R. A. (2002) *Effect of cognitive styles and two instructional modes on students' achievement in mathematics*. Unpublished M.Ed project. University of Ibadan, Ibadan.
- Aghadiuno M.C. (1992). *A Path-Analytic Study of Cognitive Style, Understanding of Science and Attitudinal Variable as Correlates of Achievement in Secondary School Chemistry*. Unpublished Ph.D. Thesis, Department of Teacher Education, University of Ibadan.
- Agina-Obu T.N. (1991). *Cognitive Styles, Problems Solving Paradigm and Achievement in Biology*. Unpublished Ph.D. Thesis, Department of Teacher Education, University of Ibadan.
- Aimunmondion, M. C.(2008). *Effects of Thought-Flow Knowledge and Shared Reading Instructional Strategies on Senior Secondary School Students' Achievement in English Reading Comprehension and Summary Writing*. Post Field Seminar Paper Presented at the Joint Staff/Higher Degree Students' Seminar Series Department of Teacher Education, University of Ibadan, Ibadan
- Akinsola, M. K. (1994). *Comparative Effects of Mastery Learning and Enhanced Mastery Learning Strategies on Students Achievement and Self-Concept in Mathematics*. Unpublished Ph.D Thesis, University of Ibadan.
- Akinsola, M. K., & Tella, A. (2001). Diagnosis of Pupils' Difficulties and Errors in Learning Mathematics in Primary School in Ibadan. *Ibadan Journal of Educational Studies*, 1(1), 118-127.
- Bailey, T. (2002). Taking the Problems out of Word Problems. *Teaching Pre K-8*, 32(4), 60-61.
- Balogun, T. A. (1993). *Gender Issues in the Teaching of Science, Technology and Mathematics*. Paper Presented at the Roundtable on Women in Science and Technology in Nigeria. Feb., 22-23.
- Bates, E. T., & Wiest, L. R. (2004). Impact of Personalisation of Mathematical Word Problems on Student Performance. *The Mathematics Educator*, 14(2), 17-26.
- Coolican, H (1994). *Research methods in Psychology*, (2<sup>nd</sup> ed.) London: Hodder and Sloughlon Education.
- d'Ailly, H. H.; & Simpson, J. (1997). Where Should 'You' Go in a Math Compare Problem? *Journal of Educational Psychology*, 89(3), 567.

- Davis-Dorsey, J. K. (1989). *The Role of Context Personalisation and Problem Rewording in the Solving of Math Word Problems*. Unpublished Doctoral Dissertation, Memphis State University.
- Dorothy, R. (1991). *Diagnosis and Correction in Reading Instruction*. Allyn and Bacon, London.
- Ensign, J. (1997). *Linking Life Experiences to Classroom Math*. Paper Presented at the Annual Meeting of the American Educational Research Association, Chicago, IL.
- Fakeye, D.O.(2006). Componential Analysis as a Model of ESL Vocabulary Instruction. *African Journal of Educational Research*,10(1 & 2), 14-24.
- Gustafson, K. L (1995). *Instructional Design Models*. in the International Encyclopedia of Education (Eds) Torsten Husen and T. Neville Postlethwaite Second Edition, Vol.5
- Hart, J. M. (1996). The Effect of Personalised Word Problems. *Teaching Children Mathematics*, 2(8), 504-505.
- Ige, T.A (2001). Concept of Mapping and Problem-Solving Teaching Strategies as Determinants of Achievement in Secondary School Ecology. *Ibadan Journal of Educational Studies* 1(1), 290-301.
- Jiboku, O. A. (1998). *The Relative Effectiveness of Critical Reading & Semantic Mapping Instructional Strategies on Secondary School Students Learning Outcomes in Reading Comprehension*. Unpublished Ph.D. Thesis University of Ibadan.
- Ku, H-Y. & Sullivan, H. J. (2000). Personalisation of Mathematics Word Problems in Taiwan. *Educational Technology Research And Development* 48(3), 49-59.
- Ku, H-Y., & Sullivan, H. J. (2002). Student Performance and Attitudes Using Personalised Mathematics Instruction. *Educational Technology Research and Development*, 50(1), 21-33.
- Lopez, C. L. (1989). *Levels of Personalisation and the Achievement and Attitudes of Hispanic Students*. Unpublished Doctoral Dissertation, Arizona State University.
- Lopez, C. L. & Sullivan, H. J. (1992). Effect of Personalisation of Instruction Context on the Achievement and Attitudes of Hispanic Students. *Education Technology Research and Development*, 40(4), 5-13.
- MacGregor, S. K, Shapiro, J. Z. & Niemiec, R. (1988). Effects of a Computer-Augmented Learning Environment on Math Achievement for Students with differing Cognitive Style. *Journal of Educational Computing*, 4(4), 453-465.
- Maduabuchi, N. (2002). *Methods of Teaching Vocabulary in Secondary Schools*. Unpublished M.Ed Project, University Of Ibadan.
- Messick, S. (1984). The nature of Cognitive styles: Problems and Promise in educational practice. *Educational Psychology*, 19, 59-74.

- Murphy, L. O., & Ross, S. M. (1990). Protagonist Gender as a Design Variable in Adapting Mathematics Story Problems to Learner Interests. *Educational Technology, Research and Development*, 38(3), 27-37.
- Nwosu F.C (2002). *Effects of Four Holistic Instructional Strategies on Senior Secondary School Students' Reading Comprehension in Ibadan*. Unpublished Ph.D. Thesis University of Ibadan.
- Obemeata, J. O. (1974). Predictive validity of Intelligence tests M, ML, and MQ. *African Journal of Educational Research*, 1(2), 205-211.
- Odiaka S. I. (2002). *Effects of Holistic & Subskill Instructional Approaches & Content Area Reading Comprehension Among Some Junior Secondary School Students in Ibadan Metropolis*. Unpublished Ph. D. Thesis, University of Ibadan.
- Olaboopo, A.O. (1999). *Relative Effectiveness of Outlining, Pre-Questions and Graphic Organizers on Students' Achievement, Attitude to, and Motivation for Composition Writing*. Unpublished P.hD Thesis, University of Ibadan.
- Oladeji, F. (1997). *Problem Solving Strategy and Students' Achievement in Mathematics among some Selected Senior Secondary Schools in Ibadan*. (M.Ed Project) University of Ibadan.
- Olajengbesi (2006). *Effects of Concept Mapping and Problem Solving Instructional Strategies on Students' Learning Outcomes in Chemistry*. An Unpublished M.ED Project. University of Ibadan.
- Olaleye, O. O. (1997). *Problem Solving Strategy and Students' Achievement in General Mathematics among some Selected Senior Secondary Schools in Ibadan*. (Unpublished M.Ed Project) University of Ibadan.
- Onabanjo, C. F. (2004). *A Survey of Some Behavioural and Attitudinal Factors Affecting Senior Secondary School Female Students' Mathematical Ability and Achievement*. Unpublished Ph. D Research Post-Field Report University of Ibadan.
- Onyejiaku F.O. (1980). *Effects of Two Cognitive Styles and the Relative Effectiveness of Two Teaching Methods on the Learning of Mathematics*. Unpublished Ph.D. Thesis. Department of Teacher Education, University of Ibadan
- Oyedeji, O. A. (1996). Assessing Gender Factor in Some Science and Mathematics Texts in Nigeria. *Zimbabwe Journal of Education Research*, 8(1), 45-53.
- Polya, G. (1945). *How to Solve it*. 2<sup>nd</sup> edition, Princeton University Press.
- Renninger, K. A., Ewen, L., & Lassher, A. K (2002). Individual interest as context in expository text and mathematical word problems. *Learning and Instruction*, 12, 467-491
- Riding, R.I & Al-Salih, N (2000). Cognitive Style and Motor Skill and Sports Performance. *Educational Studies* 26 (1), 19-32.



- Roberge, J. J. & Flexer, B. K. (1983). Cognitive style, Operativity and Mathematics Achievement. *Journal for Research in Mathematics Education*, 14(5), 344-353
- Ross, S. M. (1983). Increasing the Meaningfulness of Quantitative Material by Adapting Context To Student Background. *Journal of Educational Psychology*, 75(4), 519-529.
- Ross, S. M. & Anand, P. G. (1987). A Computer-Based Strategy for Personalizing Verbal Problems in Teaching Mathematics. *Educational Communications and Technology Journal*, 35(3), 151-162.
- Scott, N. C. (1977). Inquiry Strategy, Cognitive Style and Mathematics Achievement. *Journal for Research in Mathematics Education*, 8(2), 132-143.
- Vaidya, S. & Chansky, N. M. (1980). Cognitive Development and Cognitive Style as factors in Mathematics Achievement, *Journal of Educational Psychology*, 72(3), 326-330.
- Witkin, H. A., Moore, C. A., Goodenough, D. R & Cox, P. W. (1977). Field-dependent and field-independent cognitive styles and their educational implications. *Review of Educational Research*, 47, 1-64.
- Wright, J. P., & Wright, C. D. (1986). Personalised Verbal Problems: An Application of the Language Experience Approach: *Journal of Educational Research*, 79(6), 358-362.

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