Ife Journal of Theory and Research in Education

ISSN: 0794-6754

IJOTRE

Journal of the Institute of Education

Obafemi Awolowo University,
Ile-Ife.

Bi-Annual

VOL 11 No. 1 & 2 2008

ISSN: 0794-6754

Ife Journal of Theory and Research in Education

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Obafemi Awolowo University
Ile Ife.

Bi-Annual
Vol.11 No. 1 & 2, 2008

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References should be arranged in alphabetical order according to the surnames of the authors. Footnotes are not allowed.

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EFFECTS OF COGNITIVE ENTRY CHARACTERISTICS AND GENDER ON STUDENTS'COGNITIVE ACHIEVEMENT IN BEARING

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Abstract

There are evidences that showed that most Nigerian Students tend to dread and fail mathematics. Bloom (1981) Bloom theory of learning (Based on mastery learning studies) tends to suggest that this needs not be, he asserts that if students enter into learning situation with adequate level of Cognitive Entry Characteristics (CEC), most students are assure of high degree of learning. Under this situation according to him aptitude ceases to predict achievement. This study sought to see the application of Bloom's (1981) theory to learning of bearing under an Experimental setting.

This study used a quasi experimental research type to find the effect of CEC on students' Cognitive achievements in bearing. Two hundred and twenty seven SS 2 students were involved. The sample was drawn using multi-stage sampling technique to select two public co-educational secondary schools each, from two selected Local Government Areas in Ibadan Metropolis. The instruments used for data collection were the, Mathematics Achievement Test, with reliability coefficients of 0.75 and Diagnostic Tests. The data collected were analysed using ANCOVA to find the effect of CEC and gender on students' cognitive achievement.

The study found out that at 0.05 level of significance, CEC and gender with f-ratios of 79.832 and 7.045 respectively have significant main effects on Students' Cognitive achievement in bearing. CEC and gender however, have no significant interaction effect on cognitive achievement of students in bearing.

The results support the theory of Bloom (1981) that students with adequate level of CEC tend to achieve high degree of learning. This tends to suggest that failure rate in mathematics can be reduced if teachers ensure that students come into learning situation with necessary CEC.

Introduction

Despite the importance attached to Mathematics at different level of education, students tend to perform poorly in it. In fact the level of performance of Nigerian students in Mathematics compared with those of students from other countries taking Senior Secondary school certificate examination conducted by WAEC is very poor.

Table 1: Students Performance in Mathematics from 1992 –1999 for Nigeria, Ghana, Sierra Leone, Gambia and Liberia.

COUNTRY	%CREDIT (A1-C6)	%PASS (P7-P8)	%FAILURE
GHANA	37.6	30.0	32.4
GAMBIA	30.1	22.5	47.4
SIERRA LEONE	17.8	17	65.2
LIBERIA	17	57.6	25.5
NIGERIA	13.7	34.1	51.3

Source; WAEC Research And Statistics Unit

From the table above, it can be seen that the students performance in mathematics (A1 – C6) within the period was highest in Ghana (37.6%) and lowest in Nigeria (13.7%). Even students in a war-ravaged Liberia had a better outing with 17%. This has resulted in calls for mathematics topic analysis to identify areas where students seem to have problems

West Africa Examination Council Chief examiners' reports (1997, 1999, 2000) identified Geometry and trigonometry as the areas in which most of the students performed poorly year in year out. Adeleke (2007) also found that majority of secondary school students indicated that Bearing is their 'dislike' topic in mathematics. What then could be responsible for this poor performance in geometry in general and bearing in particular? Several attempts have been made by some researchers to identify factors associated with students' level of learning mathematics. Abadom, (1993), Iso (1992) and Udousoro (2000) identify several factors which include anxiety, motivation, reasoning ability, problem-solving skills, and instructional Strategy. Yet failure is still being experienced among students.

Bloom, after an exhaustive review of literature, drew attention to an alterable variable that he believes accounts for most learning outcomes. He referred to this as Cognitive Entry Characteristics (CEC). His analysis points to the fact that CEC account for 50% of the variations in learning outcome. What then is the Cognitive Entry Characteristics (CEC)? Bloom defines cognitive entry characteristics as the specific knowledge, abilities, or skills which are essential pre-requisites for the learning of a particular school subject or a particular learning task. According to Bloom, such prerequisites typically correlate +0.70 or higher with measures of achievement in a subject. He explains further that when they are identified and measured, they replaced intelligence or aptitude in the prediction of later achievement. Bloom hypothesizes further that cognitive entry characteristics have an obvious causal effect on later cognitive achievement.

Bloom (1981) suggested that if all the learners come into a learning situation with adequate levels of cognitive entry characteristics, all or most of them can attain a high degree of learning. He corroborated his theory by proposing that one can demonstrate this in learning studies, by teaching and enhancing topics that provide learners with basic skills, knowledge abilities before they proceed to a particular learning task and find out how well they learn a new learning task to mastery in comparison with those who widely vary in possession of cognitive entry characteristics Bloom,(1974).

In tune with Bloom, (1974) proposition, Oyedeji (1987) carried out an empirical study where he used 121 forms four Nigerian Secondary School Students to find the effect of sequencing instruction after a validated learning hierarchy on Students' learning outcome. He ensured that most students attained mastery of any given task before proceeding to the next related higher task on the hierarchy. His instructional content was school certificate algebra. He tested his hypothesis at 0.05 level of significance. He found that the experimental group on which the validated hierarchy was used, showed superior cognitive outcomes in acquisition of the subject matter taught to the control group. This tends to suggest that enhancement of CEC may lead to high levels of cognitive achievements

Abadom's (1993) study also supported that of Bloom (1974) that most of the variation in school learning is directly determined by Cognitive Entry Characteristics (CEC). She found that Enhancement of Cognitive Entry Characteristics lead to high levels of Cognitive achievement and the mean scores of experimental group 1, 2 and control were 78.7%, 53.3% and 49.9% respectively on the achievement test. She also found that the difference between the experimental group 1 (High Level of CEC) and the other groups were significant ($P<0.001$). Her finding also supports Bloom's (1974) proposition on the efficacy of CEC when enhanced in producing students' better cognitive achievement. Both Oyedeji, (1987) and Abadom, (1993) based their studies on Secondary School Algebra, but this study sought to test the efficacy of CEC on Bearing as an identified difficult topic in mathematics where majority of students performed poorly from year to year (WAEC Chief Examiners' Reports, 1997, 1999, and 2000).

Research findings on gender differences in classroom mathematics achievement have attracted the interest of many researchers and educators in the recent time (McGinnis and Pearsall, 1998; Popoola 2002; Kelly, 2003). In spite of the existence of many of such studies, more investigations are being undertaken in this area. This is because a definite and stable picture of gender differences in mathematics achievement is yet to emerge. Popoola (2002) concluded that there is no effect of student gender on achievement in algebra aspect of mathematics. As part of the researcher's contribution to the debates surrounding the impact of gender on students performance in various aspects of mathematics, this study sets out to

investigate whether gender will also have effect on students' performances in geometry. Bearing this in mind, the gender of the students would be a controlled factor in this study while looking at the effect of cognitive entry characteristics on students' learning achievement in bearing.

This study therefore involved SS2 students and the mathematics topic that was taught among the two groups was bearing.

Statement of Problem

This study sought to find the effects of this Cognitive Entry Characteristics (CEC) on students' cognitive achievement in bearing. It also sought to find the main effect of gender as well as interaction effect of CEC and gender on students' achievement in bearing.

Research Questions.

Based on the stated problem, the following research questions would be answered.

1. What is the main effect of (a) CEC and (b) gender on students' cognitive achievement in bearing?
2. What is the 2-way interaction effect of CEC and gender on students' cognitive achievement in bearing?

Significance of the Study.

The results of the study on all possible main and interaction effects of independent and moderator variable on the dependent variables would be significant addition to the basic data needed for planning and executing a more effective theory and technique of teaching bearing to secondary school students. All these are likely to have implications on secondary school curriculum planning, teaching, training and retraining programmes, counseling services and classroom practice.

Methodology

Research design

This study used a quasi experimental research type with a 3x2x3 non-randomized pretest and posttest control group, factorial design.

Outline of design

The outline of design is as follows:

Experimental group 1 - O_1 X_1 O_2 O_3

Control group - O_1 X_2 O_3

Where
O_1 . represent pretest measure.
O_2 - represent diagnostic test (formative test)
O_3 represent posttest.(Summative test).
x_1 – structured instruction with cognitive entry characteristics, formative test, and immediate feedback corrective.
X_2 –conventional method of instruction.

Block design

Table 2. Showing 2x2 factorial designs.

Treatment variable	Gender	
	Male	Female
Enhanced CEC		
Conventional method Instruction		

Sample

The study used multi-stage sampling technique. Two Local Government Areas (LGAs) were randomly selected from the five existing ones in Ibadan metropolis. Two public coeducational secondary schools were selected from each of the selected LGA using simple random sampling. An arm of SS2 science classes was randomly selected from each school and all the students in the class were part of the experiment. The distribution of the schools and the students selected for the experiment are presented in table 3 below.

Table 3. Distribution of Schools and students used for the Experiment .

Ibadan LGA	Total No of Senior co-educational Sec. schools	No of selected co-educational schools	No. of selected Students
North	23	2	108
South West	19	2	119
Total	**42**	**4**	**227**

The school type as a variable was not controlled for in this study, therefore, private schools were excluded from the sample, so also single sex schools. The SS2 class was selected for the study for the following reasons:

- The National Curriculum in Mathematic stipulates that bearing which is the target task should be taught at SS2

- SS2 is not an examination class like SS3 that focuses on preparing students for external examination which can invariably affect the study negatively.

Instrumentation

Instruments:

Three instruments were used for this study. They are:

(1) Pretest(Mathematics Achievement Test)
(2) Diagnostic test.
(3) Posttest (Mathematics Achievement Test)

(1) Mathematics Achievement Test (MAT) - Pretest. This is a validated 20-item multiple-choice test with four options. Kuder Richardson formula 20 was used to establish the internal consistency of the instrument. The reliability coefficient is 0.8 and the difficulty index (p) is 0.4. The content validity of MAT was established by using the scheme of work for mathematics to develop the items across the cognitive domains-knowledge, comprehension, application, analysis, synthesis, and evaluation stated in (Bloom, Hastings and Madaus 1971). A sample of 119 SSII students similar to target sample from a co-educational secondary schools who have completed bearing in their mathematics syllabus was used for the test item analysis of MAT.

(2) Diagnostic Test.

There are eight diagnostic tests used for the study. Each is a 10-item formative test of 4 options scale that was used to measure learning difficulty after each unit of instruction.

(3) Mathematics Achievement Test (MAT) - Posttest

It is the same version of Mathematics Achievement Test (MAT)- Pretest

Procedure for the Experiment

The following steps were taken to carry out the experiment:

- The authorities of the selected schools were met for permission which was given and the researcher gave details on how the work would be carried out.
- At first, contact familiarization lecture was given to the selected students where the purpose of the study was explained,
- The treatments were randomly assigned to each of the selected schools.
- Subjects were taught using the prepared module on the validated units of the CEC.
- Formative tests were used to diagnose the learning difficulties.

- The scripts were scored as soon as the test was over. This provided immediate feedback.
- The test was then reviewed giving the correct options.
- Peer tutoring was used to provide remediation for slow learners. Those learners that scored above 80% were classified as peer tutors while those who scored below average were classified as slow learners. The peer tutors were paired with non-master for peer tutoring. Pairing of non-master students with peer tutors sometime did not visible especially when the peer tutors were few during the teaching of any unit. In such situation, the teacher in charge used to do the enhancement. 80% of the learners attained mastery on a unit before moving forward to the next unit.
- The Mathematics Achievement Test (Post test) was administered after bearing was taught.

Control Group

- Subjects in this group received instruction on bearing but they were taught using the conventional method.
- The Mathematics Achievement Test (Post test) was administered before and after all the units have been taught.

Data Collection

The teachers used for both the experimental and control groups were the mathematics teachers teaching the class normally but each of them has at least B.ed mathematics. This was done to control for some extraneous variables that may be introduced as a result of using one teacher for the two groups or the researcher handling the groups by himself. However the teachers for experimental groups were trained on how to use the modules prepared by the researcher but the teachers for the control group proceeded in the normal way in which he teaches. Data collection last for 9 weeks.

Data Analysis

ANCOVA and MCA were used to establish the effects of independent on the dependent variables. However those that took all the necessary tests among the sample were included in ANCOVA analysis result of this investigation.

RESULTS

Research Question One.

What is the main effect of: (a) CEC and (b) Gender on Students' Cognitive achievement in bearing?.

Table 4. ANCOVA on the effect of CEC, Gender and Aptitude on Students' cognitive achievements bearing. In

ANOVA[a,b]

			Experimental Method				
			Sum of Square	df	Mean Square	F	Sig.
POSTTEST	Covariates	PRETEST	30.033	1	30.033	3.351	069
	Main Effects	(Combine)	839.778	2	419.889	46.854	000
		Treatment	715.423	1	715.423	79.832	00
		Gender	63.133	1	63.133	7.045	009
	2-Way Interactions	Treatment * Gender	1.986E-02	1	1.986E-02	.002	963
	Model		869.831	4	217.458	24.265	000
	Residual		1156.050	129	8.962		
	Total		2025.881	133	15.232		

Table 4: shows that there is significant main effects of CEC [$F_{(1,129)}$ =79.83; $p<0.05$]and gender [$F_{(1,129)}$ =7.05; $p<0.05$] on students' cognitive achievement in bearing.

Table 5: MCA: Cognitive Achievement in Bearing by CEC, and Gender

Variable + Category.	N	Unadjusted Dev	Eta	Adjusted for Independents	Beta
CEC					
Enhanced CEC	65	2.509		2.403	.600
Control	69	-2.36	.626	-2.264	
GENDER					
Male	66	-1.000	.253	-.702	.178
Female	68	.970		.6817	
Multiple R. Square					.429
Multiple R.					.655

Grand Mean = 8.1

As part of the ANCOVA the MCA (table 5) shows the effect of each of the conditions before and after, while difference in gender was controlled for. The column on unadjusted deviation shows that before adjustment were made for gender, the effect of Enhanced CEC, and control levels on cognitive achievement were 2.509 and -2.36 respectively. After adjustment had been made, the effects became 2.403 and –2.264 respectively. That is to say that the higher the level of CEC, the higher the level of Cognitive achievement in the target task. In particular, the eta value 0.626 shows that when adjustments were not made for the covariates (pretest scores in (MAT), CEC accounted for 39.19 percent of the variation in

learning achievement. When the scores were adjusted, CEC accounted for about 36 percent of the variation in cognitive achievement in bearing.

Also the column on unadjusted deviation shows that before adjustment were made for CEC the effect of male and female levels on cognitive achievement in bearing were -.1 and .970 respectively. After adjustment had been made, the effects became -.702 and .682 respectively. That is to say that the different level of gender cause different level of Cognitive achievement in the target task. In particular, the eta value .253 shows that when adjustments were not made for the covariates (pretest scores in (MAT), gender accounted for 6.4 percent of the variation in learning achievement. When the scores were adjusted, gender accounted for about 3.2 percent of the variation in cognitive achievement in bearing. CEC, and gender jointly accounted for 42.9 percent of the variation in Cognitive achievement in bearing.

Table 6: T test comparison on Pretest and Posttest

	Pretest				Post test			
Variable	N	Mean	SD	$t_{Observed}$	N	Mean	SD	$t_{Observed}$
Enhanced CEC	96	2	2.46	-3.41*	80	10.56	3.44	9.78*
Control Group	118	3.067	2.12		70	5.69	2.52	

*** $t_{observed}$ is significant at 0.05 level of significant**

Table 6 shows that the control group performed better significantly than the experimental group in the pretest. However after the experiment, the mean score of the experimental group almost doubled that of the control group.

Research Question Two.

What is the 2-way interaction effect of CEC and gender on students' cognitive achievement in bearing.

As shown in table 4., there is no significant interaction effect of CEC and gender [$F_{(1,129)}$ =0.002; p>0.05] on students' cognitive achievement in bearing at 0.05 alpha level. This implies that CEC is not having significant effect on cognitive achievement when male and female students are taken separately.

Discussion.

It was found that CEC and gender have significant main effect on cognitive achievement in bearing. This corroborates the Bloom's (1981) speculation that when means are found for ensuring that students reach adequate levels of

competence on the essential cognitive entry characteristics (CEC), most students can be assured of achieving highly in school learning. The vast difference between the enhanced CEC and control group is traceable to learning difficulties that had been taken care of before entering into the learning task. This made their mean cognitive achievement almost double the achievement of the control group that performed better in pretest. There is need to shift attention from variables that reside outside the learners (since majority of them are not easily alterable) to those that directly center on them, that is, learners characteristics. This is important because CEC alone contributes above 36 percent to the variation observed in learning achievement. The result supported the view of Bradley (2003) and the finding of Oyedeji (1987) and Abadom (1993) that the difference in student academic achievement could be typically explained by students' individual cognitive characteristics. If necessary CEC are taught and enhanced before the final learning task, students will surely perform well (Abadom, 1993).

Gender is another variable found in this study to significantly affect cognitive achievement. There was a claim that male perform better than female in mathematics among educators (Baron- Cohen, 2003; Casey, Nuttal, Pezaris, and Bembow, 1995; Geary, 1998; Kimura, 1999). Some others claimed equality in performance among male and female students in mathematics (Halpern, Wai, And Saw 2005; Pinker, 2002). The result of this study turned out to favour female students in cognitive achievement in mathematics. Female students achieved significantly more than male students. This suggests that the stable position on gender differences in mathematics achievement is yet to be reached.

Conclusion.

The findings of this study have meaningful implications for classroom mathematics teachers, curriculum planners and educational evaluators. Based on the results of the study, it is clear that students that lack basic cognitive entry characteristics to a reasonable level are bound to achieve less in the overall summative test. The findings have implication for the classroom teachers especially mathematics teachers. They should

Painstakingly work on each topic especially in mathematics, identify prerequisites that will constitute the Cognitive Entry Characteristics (CEC) for the intended topic and strategize on ways to enhance those CEC for better achievement in the topic. School teachers and counselors need to work on male students to motivate them to learn bearing effectively as many of them who will go for Engineering courses will need the knowledge in the future.

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