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PATH – ANALYTIC STUDY OF COGNITIVE ENTRY CHARACTERISTICS AND STUDENTS' ACHIEVEMENT IN BEARING IN MATHEMATICS

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ABSTRACT

Individual differences in learning outcomes have been observed by many researchers in the past. Bloom (1974) proposed that the Cognitive Entry Characteristics are alterable variables that account for the greatest degree of variance in students' learning. This study, therefore, validated a causal model that involved Cognitive Entry Characteristics (CEC) and student achievement in bearing in Mathematics.

The study is an ex-post facto type. Four hundred and ninety two SS 3 students were involved in the study. The samples were drawn using multi-stage sampling technique from public co-educational secondary schools in three of the five local government areas in Ibadan Metropolis. The instruments used for data collection were the Mathematics Achievement Test (r = 0.80, P = 0.4) and Diagnostic Tests measuring the CECs. The data collected were analysed using path analysis (a path between causal factor and dependent variable was retained if $/P_{ji}/ \geq 0.05$ and r_{ij} is significant at 0.05 alpha level).The study revealed that all the hypothesized CEC were found to have either direct or indirect effect or both on students' achievement in bearing. This has implications for education, especially the curriculum developers and classroom teachers, particularly on the need for learning sequence. It was therefore recommended that equipping students with adequate level of Cognitive Entry Characteristics that would enhance high degree of cognitive achievement be considered by teachers.

BACKGROUND TO THE STUDY

Mathematics is made a compulsory subject at primary and secondary school levels, because its understanding dictates how an individual copes with day to day activities as well as daily interactions with others. According to Oladele, (2004), all students are not expected to become mathematicians but they need an application of Mathematics in everyday life. Mathematics is also a useful tool in the society, especially in the present technology age. Babalola (1991) corroborated this view by saying that Mathematics is a basic tool in the development of science based knowledge such as technology, industry and even for sound analytical reasoning in daily living in a modern society such as ours. In view of its importance, Mathematics is a subject that students in secondary schools have to be taught at least four times a week. This is to ensure that the students understand the subject very well. Despite the importance attached to it, students tend to perform poorly in Mathematics in both secondary and tertiary institutions.

The level of performance of Nigerian students in Mathematics compared with countries such as Ghana, Gambia, Sierra Leone and Nigeria that take Senior Secondary School Certificate Examinations conducted by West African Examinations Council (WAEC) is very poor. In fact, Nigeria has the lowest percentage of students that scored between A1 and C6 in Mathematics between 1992 and 1999 (Table 1.1). Nigeria recorded only 13.7% average over a period of nine years. It was 37.6% in Ghana, 17.8% in Sierra Leone, and 30.1% in Gambia. Even Liberia, a country ravaged by war recorded 17.0%.

Table 1.1: 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; West African Examinations Council Research And Statistics Unit

Several attempts have been made by some researchers to identify factors associated with students' level of achievement in mathematics. These factors include: (i) anxiety (Abadom, 1993) (ii) motivation (Abadom, 1993) (iii) reasoning ability (Abadom, 1993) (iv) problem-solving skills (Udousoro, 2000) and (v) instructional Strategy (Iso, 1992, Udousoro, 2000,), yet the problem of poor students' achievement is being experienced from year to year.

Bloom (1976), after an extensive review of literature, drew attention to an alterable variable that he believes may account 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, (1976) such prerequisites are likely to correlate (+0.70 or higher) with measures of achievement in a subject. He explains further that when they are identified and measured, they replace intelligence or aptitude in the prediction of later achievement. Bloom hypothesizes further that cognitive entry characteristics may have causal effect on later cognitive achievement. On the basis of the foregoing, this study was set to investigate the causal effects of knowledge of fraction, decimal and algebraic fraction, algebraic process, angles and triangle, trigonometry, specifying bearing, presentation of bearing with diagram, cosine rule and sine rule on students' achievement in bearing.

STATEMENT OF PROBLEM

This study constructed and tested an eight-variable path analytic model on students' cognitive achievement in bearing. It also provided a causal explanation of students' cognitive achievement in terms of CECs: fraction, decimal and algebraic fraction, algebraic process, angles and triangle, trigonometry, specifying bearing, presentation of bearing with diagram, cosine rule and sine rule.

RESEARCH QUESTIONS.

Based on the stated problem, the following research questions were answered:

1. What is the most meaningful causal model involving the listed CECs and students' cognitive achievement in bearing?
2. What are the directions as well as the estimates of the strengths of the causal paths of the variables in the model?
3. How consistent is the model with the existing data?

METHODOLOGY

RESEARCH DESIGN

This study is an ex-post facto (non-experimental) research.

SAMPLE

This study used a multi-stage sampling technique. Three Local Government Areas (LGA) were randomly selected from the five existing ones in Ibadan metropolis. Cluster sampling was also employed and the selected LGAs formed the clusters. Ten schools were selected from the three clusters, using the method of sampling proportion to size, that is, the number of eligible co-educational senior secondary schools in each cluster (selected LGA). An intact science class was randomly selected from each of the selected schools.

INSTRUMENTS

Two instruments were used for this study. They are:

(1) Mathematics Achievement Test (MAT)

(2) Diagnostic tests.

(1) Mathematics Achievement Test (MAT). 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 (Bloom, Madaus, & Hastings, 1981). A sample of 119 SSII students similar to target sample from co-educational secondary schools in Ibadan metropolis who have completed bearing in their mathematics syllabus were used for the test item analysis of MAT.

(2) Diagnostic Tests.

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 of the following units of instruction: fraction, decimal and algebraic fraction, algebraic process, angles and triangle, trigonometry, specifying bearing, presentation of bearing with diagram, cosine rule and sine rule. The tests were constructed by the researcher.

PROCEDURE

The selected schools were visited by the researcher; assistance of all the Mathematics teachers in the concerned schools were sought in administering the instruments to the selected students. The data generated was used for the validation of the hypothesized linkages. Six structural equations labeled 3.1 to 3.6 were formed. Each equation corresponds to each dependent variable X_i ($i = 4$, 5,6,7,8, and 9).

(1) $X_4 = P_{41}X_1 + P_{42}X_2 + P_{43}X_3 + e_4$ 3.1

$X_5 = P_{51}X_1 + P_{52}X_2 + P_{53}X_3 + P_{54}X_4 + e_5$ 3.2

$X_6 = P_{61}X_1 + P_{62}X_2 + P_{63}X_3 + P_{64}X_4 + P_{65}X_5 + e_6$ 3.3

$X_7 = P_{71}X_1 + P_{72}X_2 + P_{73}X_3 + P_{74}X_4 + P_{76}X_6 + e_7$ 3.4

$X_8 = P_{81}X_1 + P_{82}X_2 + P_{83}X_3 + P_{84}X_4 + P_{87}X_6 + P_{87}X_7 + e_8$ 3.5

$X_9 = P_{91}X_1 + P_{92}X_2 + P_{93}X_3 + P_{94}X_4 + P_{95}X_5 + P_{96}X_6 + P_{97}X_7 + P_{98}X_8 + e_9$ 3.5

Where X_1 – Score on Fraction, Decimal and Algebraic Fraction.

X_2 - Score on Algebraic process.

X_3 - Score on Angles and Triangle.

X_4 – Score on Trigonometry.

X_5 – Score on Specifying bearing.

X_6 – Score on Presentation of Bearings with diagram.

X_7 – Score on Cosine Rule.

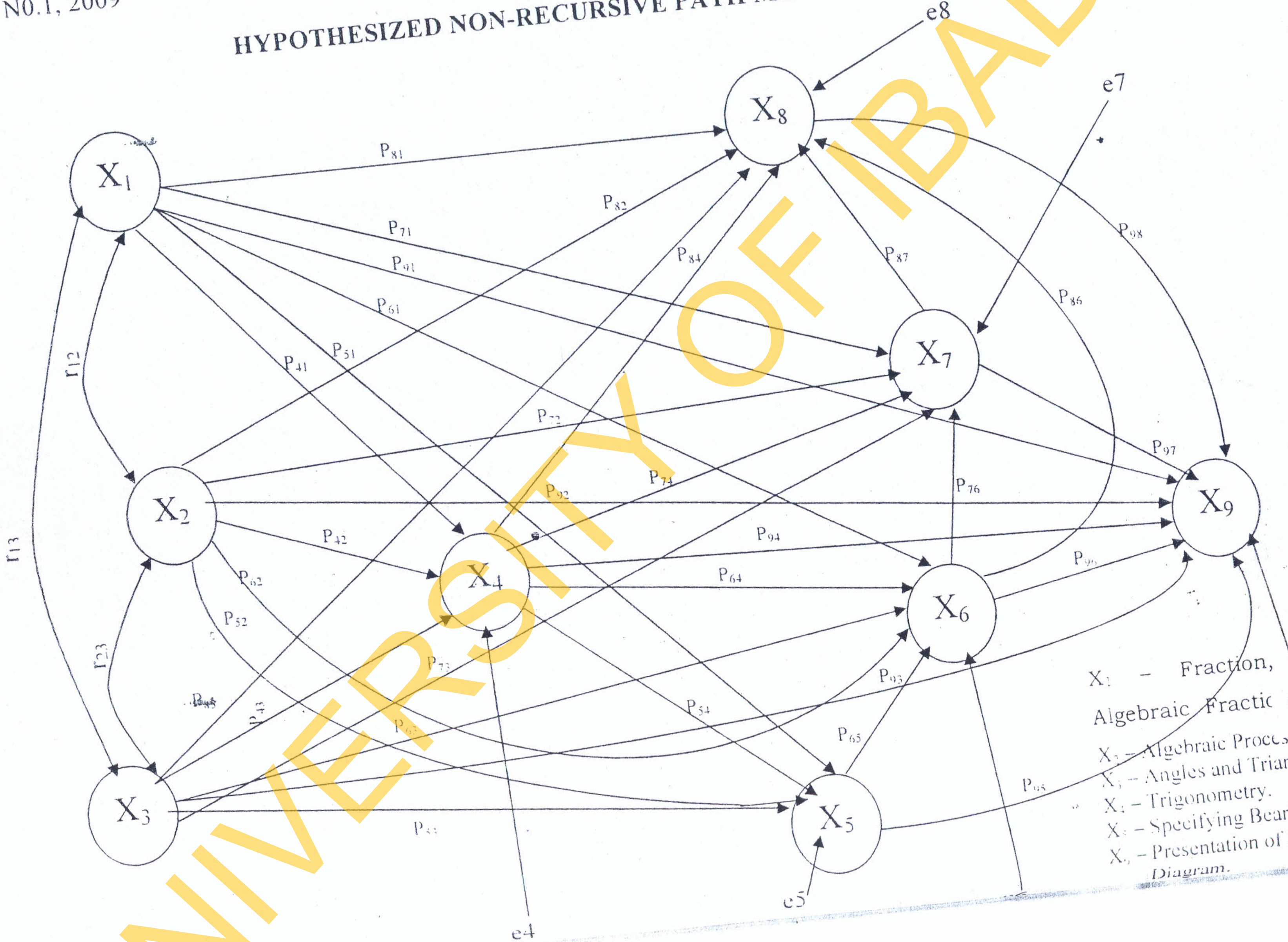
X_8 – Score on Sine Rule.

X_9 – Score on Bearings.

The significance (at the pre-specified level of 0.05) of the path coefficients that are considered meaningful was the basis for trimming the paths of the hypothesized linkages. This study used two types of criteria to determine whether a path is significant or not. Usually three types of criteria may be used in path trimming that is statistical significance, or meaningfulness or both. In this study, for meaningfulness, the absolute value of a path coefficient was taken to be at least 0.05 as recommended by Land (1969) cited by Utoh (2006). For the significance criterion, the choice of the investigator is at 0.05. These two criteria were applied to avoid the uncomfortable situation where some minute path coefficients were found to be significant because the analysis was based on fairly large samples (Kerlinger and Pedhazur, 1973) cited in (Utoh 2006). Based on the two criteria selected, for this study, the term "Significance" therefore connotes Statistical Significance as well as meaningfulness. The paths found not to be significant or meaningful were dropped. Those units found to be significant causal factors were retained as the identified CEC.

The hypothesized path model of CECs and achievement in bearing is presented in Fig 1.

HYPOTHESIZED NON-RECURSIVE PATH MODEL



X_1 – Fraction, Decimal and Algebraic Fraction

X_2 – Algebraic Process.

X_3 – Angles and Triangle.

X_4 – Trigonometry.

X_5 – Specifying Bearing.

X_6 – Presentation of Bearings with Diagram.

Fig 1.

THE RESULTS AND FINDINGS

RESEARCH QUESTION ONE

What is the most meaningful causal model involving the listed CECs and students' cognitive achievement in bearing?

The hypothesized Causal Model of the Nine-Variable System Showing Path and Zero Order Correlat[…] Coefficients

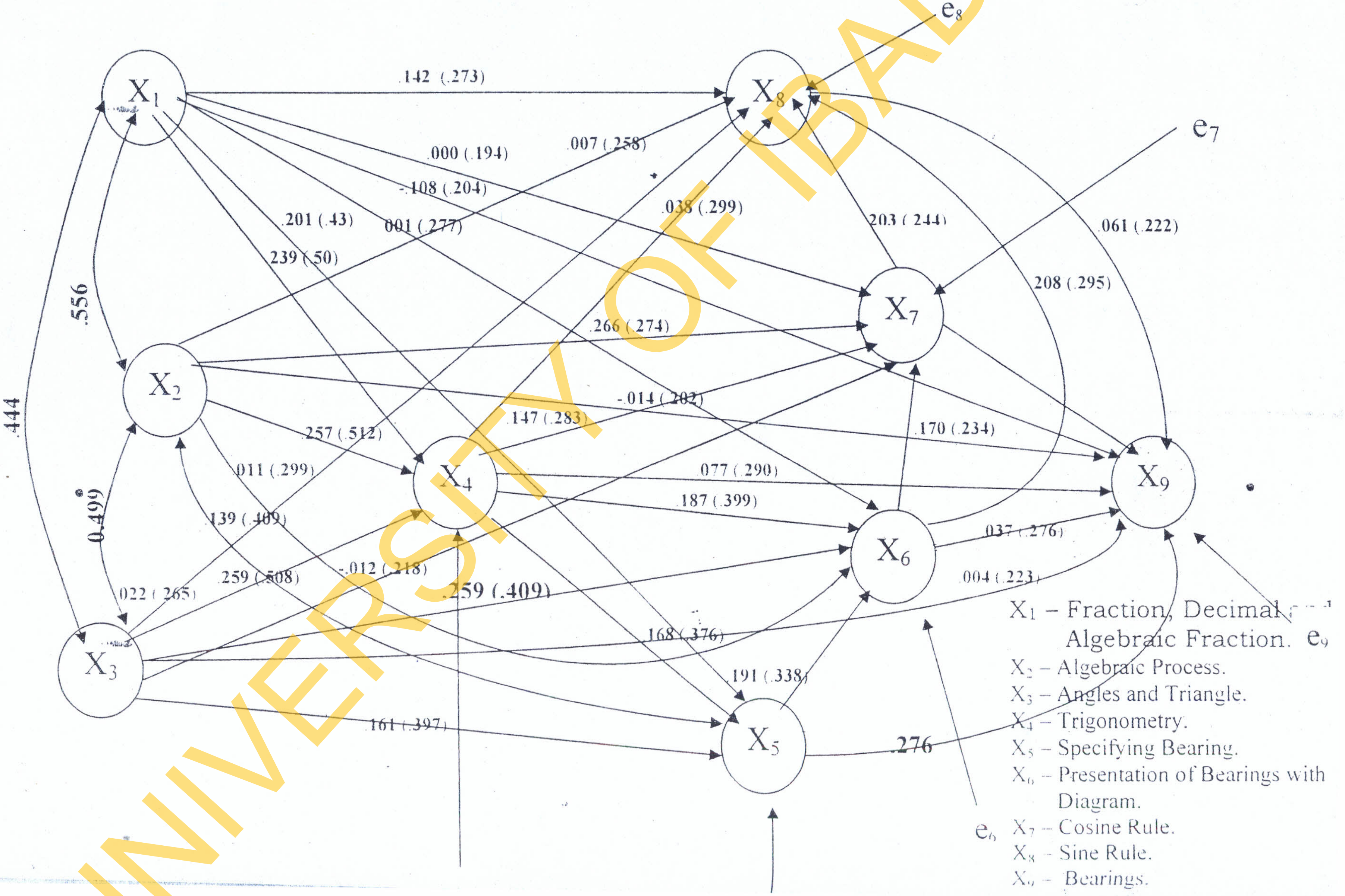
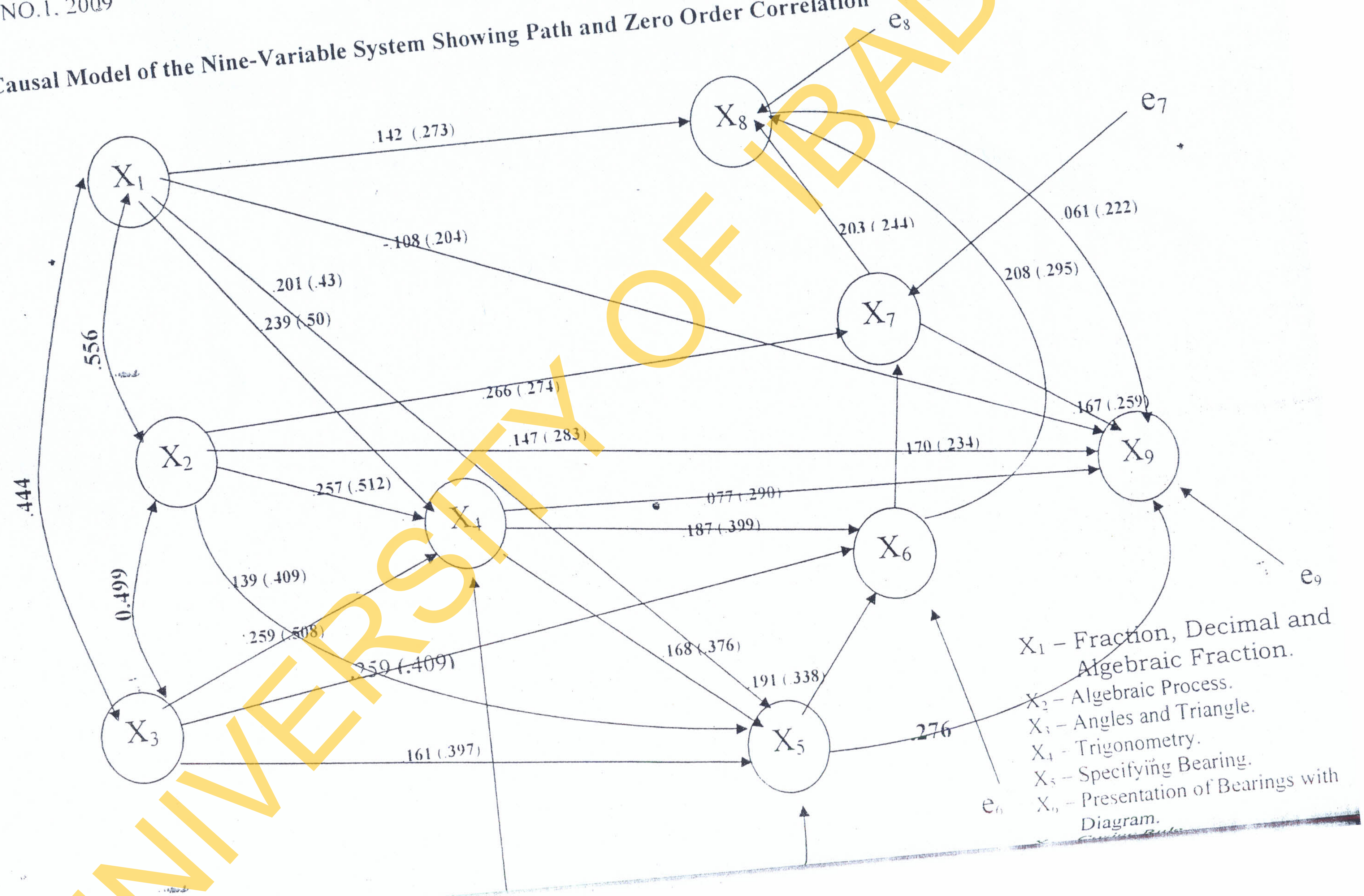


Fig. 2

The hypothesized model shown in figure 3.1 is reproduced as figure 4.1 with the path and zero order correlation coefficients written on each path way (the correlation coefficient in parenthesis). In trimming the paths in the model, paths were considered significant at 0.05 alpha level and considered meaningful if the absolute value of the path coefficient is at least 0.05 as recommended by Land(1969). Based on these criteria, the new path model (fig. 3) is obtained. Only twenty one (21) out of thirty one (31) hypothesized paths survived the trimming exercise. The survived paths are presented in fig. 3.

The Validated Causal Model of the Nine-Variable System Showing Path and Zero Order Correlation Coefficients



Research Question Two.

What are the directions as well as the estimates of the strengths of the causal paths of the variables in the model?

Table 1: Paths and Zero order Correlation Coefficients.

Path	Path coefficient	Zero Order	Decision
P_{41}	.239	.50**	S
P_{51}	.201	.43**	S
P_{61}	.001	.277**	NS
P_{71}	.000	.194**	NS
P_{81}	.142	.273**	S
P_{91}	-.108	.204**	S
P_{42}	.257	.512**	S
P_{52}	.139	.409**	S
P_{62}	.011	.299**	NS
P_{72}	.266	.274**	S
P_{82}	.007	.258**	NS
P_{92}	.147	.283**	S
P_{43}	.259	.508**	S
P_{53}	.161	.397**	S
P_{63}	.259	.409**	S
P_{73}	-.012	.218**	NS
P_{83}	.022	.265**	NS
P_{93}	.004	.223**	NS
P_{54}	.168	.376**	S
P_{64}	.187	.399**	S
P_{74}	-.014	.202**	NS
P_{84}	.038	.299**	NS
P_{94}	.077	.290**	S
P_{65}	.191	.338**	S
P_{95}	.276	.308**	S

P_{76}	.170	.234**	S
P_{86}	.208	.295**	S
P_{96}	.037	.276**	NS
P_{87}	.203	.244**	S
P_{97}	.167	.259**	S
P_{98}	.061	.222**	S

** = Correlation is significant at the 0.01 level (2 - tailed.

S⇒Significant(P_{ji} is meaningful and r_{ij} is significant).
Meaningful ⇒absolute of $P_{ji} \geq 0.05$ and significant⇒r_{ij} is significant at 0.05.

Table 1. shows the values of all the hypothesized path coefficients with their corresponding Zero order correlation coefficients. Both values were used to determine whether a path is significant or not. Any path coefficient (P_{ji}) found to be meaningful (greater than or equal to 0.05) with its corresponding zero order correlation coefficient (r_{ij}) being significant at 0.05 was retained. P_{61}, P_{71}, P_{62}, P_{82}, P_{73}, P_{83}, P_{93}, P_{74}, P_{84}, and P_{96} were found not to be significant.

Research Question Three
How consistent is the model with the existing data?

Table2: Discrepancies between the Original and the Reproduced Correlation values

Correlation (r)	Original Value	Reproduced Values	Difference
R_{14}	.500	.497	.003
R_{15}	.430	.432	.002
R_{16}	.277	.295	.018
R_{17}	.194	.186	.008
R_{18}	.273	.274	.001
R_{19}	.204	.192	.012
R_{24}	.512	.519	.007
R_{25}	.409	.439	.030
R_{26}	.299	.322	.023
R_{27}	.274	.305	.031
R_{28}	.258	.246	.012
R_{29}	.283	.324	.041

R_{34}	.508	.493	.015
R_{35}	.397	.402	.005
R_{36}	.409	.433	.024
R_{37}	.218	.188	.030
R_{38}	.265	.235	.030
R_{39}	.223	.239	.016
R_{45}	.376	.419	.043
R_{46}	.399	.401	.002
R_{47}	.202	.186	.016
R_{48}	.299	.217	.082
R_{49}	.290	.276	.014
R_{56}	.338	.378	.040
R_{57}	.146	.170	.024
R_{58}	.192	.203	.011
R_{59}	.308	.368	.060
R_{67}	.234	.247	.013
R_{68}	.295	.327	.032
R_{69}	.276	.252	.024
R_{78}	.244	.293	.049
R_{79}	.259	.193	.066
R_{89}	.222	.205	.017

Total Difference = 0.801
Mean Difference = 0.024

In order to verify the efficacy of the new model (fig 3), the reproduced correlation coefficients (based on the new path model) were compared with the original correlation coefficients. Table 2 shows the discrepancies between the original and the reproduced correlations. The discrepancies between the original and reproduced correlation were found to be very minimal. These minimal discrepancies thus indicate that the pattern of correlation in the observed data is consistent with the new model. The new path model is therefore considered to be tenable in explaining the causal interaction between the predictor variables (Cognitive Entry Characteristics: scores in Fraction, Decimal and Algebraic Fraction, Algebraic process, Angles and triangle, Trigonometry, Specifying bearing, Presentation of bearing with diagram, Cosine rule and Sine rule) and the criterion variable (Cognitive Achievement in Bearing). Figure 3 thus shows the most meaningful, causal model involving Cognitive Entry Characteristics and Cognitive achievement in bearing. This is the main result of this investigation.

DISCUSSION

From this study, it is revealed that the eight Cognitive Entry Characteristics involved in the model were found to be casuals to students' achievement in bearing and that possession of adequate level of Cognitive entry characteristics lead to high cognitive achievement in bearing,. This is in agreement with Bloom's (1974, 1981) theory and Abadom's (1993) findings. Sequencing learning tasks hierarchically leads to some improvement in performance. This finding is in agreement with Mason (2005) that learning experiences at the lower level are basic pre – requisite for learning formal geometric concepts. This finding corroborated that of Abadom (1993) that, if the prerequisite tasks have not been learned to a high enough level, they will not make much impact on the summative achievement test. This finding provides some explanation on the learning of geometry; an aspect of Mathematics many students dread.

Based on the findings of this study, it can be said that Bloom's Theory of school learning is applicable to the learning of geometry in secondary school with respect to cognitive achievement. Lending support to Bloom's theory, Abadom, (1993), said that when they come into a learning situation with high levels of necessary cognitive entry characteristics, they will attain high levels of cognitive achievement. Following her explanation, any student with learning difficulties in topics that make up CECs (fraction, decimal and algebraic fraction, algebraic process, angles and triangle, trigonometry, specifying bearing, presentation of bearing with diagram, cosine rule and sine rule) may not be able to solve problems on bearing and distances adequately. Many of them had to learn the process and figure out what was being done when each of those pre requisite skills was being brought into the solution to the problem.

RECOMMENDATIONS

Based on the findings of the study the following recommendations are offered:

1. Teachers can sequence their instructional content to include needed Cognitive Entry Characteristics (CEC) for learning a new topic instead of changing the instructional method (from traditional to modern) which has not been practically possible over the years.
2. Workshops and Seminars should be organized for teachers where they will be exposed to various enhancement strategies. This is needful to assist every student to possess adequate CEC that will lead to a meaningful achievement in the next topic to be taught.
3. The current curriculum that is in use in the secondary schools should be reviewed. The reviewed version should include basic CEC that will make

learners achieve meaningfully in a topic, as well as the enhancement strategies for assisting the slow learners.

CONCLUSION

The results and findings of this study should go beyond being additional data for understanding educational theories. It should also be regarded as a new chapter in research endeavours suggesting the integration of appropriate Cognitive Entry Characteristics to instructional activities to facilitate learning for the majority of students. This is to ensure better cognitive achievement in the dreaded subject such as Mathematics in the West African School Certificate Examinations. National Examination Council School Certificate Examinations and beyond.

REFERENCES

Abadom, G. N. (1993). Effect of Enhancement of Cognitive Entry Characteristics on the Predictive Validity of a Mathematics Aptitude Test. An Unpublished Ph.D. Thesis. University of Ibadan 24 – 57

Babalola B.A. (1991). Teaching Mathematics to Large group using the Mastery Learning Approach. *Journal of Educational Issues*. Lagos State College of Education, Oto Ijanikin, Vol. 1 No. 1 Page 147.

Bloom, B. S. Madaus, G.F. and Hastings, J.T. (1981). Evaluation to Improve Learning, Mc-Graw-Hill. Book Company, New York. 174-176.

Bloom, B.S. (1974). "*Time and Learning*" *America Psychology*. *29*.

Bloom, B.S. (1976). Learning for Mastery. *Evaluation Comment* vol.1 pg.2

Bloom, B.S. (1981). *All our Children Learning*. New York: McGralo-Hill.

Iso, E.O. (1992). The Effect of Mastery Learning on the Cognitive and Affective Learning Outcomes of Students in the Junior Secondary Two (JS2). An unpublished PGDE Thesis.

Land, K.C. (1969). Principle of Pate Analysis in Utoh. A.N. 2006.

Mason, M. (2005). The van Hiele Levels of Geometric Understanding. http://www.coe.tamu.edu/~rcapraro/Graduate_Courses/EDCI 624 625/EDCI 624 CD/literature/van Hiele Levels

Oladele O. (2004). Improving, the Teaching and Learning of Mathematics in Secondary Schools.Oyo State Mathematics Conference Paper

Udousoro, U.J. (1992). The Relative Effects of Computer and Text-Assisted programmed Instruction on Students' Learning Outcomes in Mathematics. An unpublished PhD. Thesis

Utoh. A.N. (2006). A Path – Analytic Study of Evaluation Needs of Secondary School Teachers in South – Western Nigeria. Unpublished Ph.D. Thesis. University of Ibadan.11