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Exploratory Analysis of Students' Score

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Abstract

The main thrust of this study was to determine the effect of Sex, Age, School, and Mode of Entry on performance of students in the subject Biology using Univariate Analysis of variance for the four factors (Sex, Age, School, and Mode of Entry) at two levels each factorial design. The case study is a single random sampling of 100 students selected from the 150 in a class of 200 level students from the Department of Biochemistry, Biological Sciences and Microbiology, Federal University Wukari, Taraba State, Nigeria. To achieve the purpose of this study, hypotheses were formulated to direct the study. Literature review was carried out according. Secondary data from the Department of Biological Science were used to analyse the findings of this research work. All hypotheses were tested at 0.05 level of significance. The results obtained showed that the four factors interaction is the only significant treatment in the factorial design. Eta squared showed that the four factors (Sex, Age, School, and Mode of Entry) interaction contributes the greatest to the variations in the students' scores in the subject. Noncent parameter and Observed power showed the same. The study recommended amongst other things that parents and educationists should provide enabling environment for the students by ensuring their age, school, and mode of entry is taken cognizance of as it has a significant impact on the students' performance; parents who are interested in the educational performance of their children to

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become Biologists or take up Biology and parents who are tending to mould their children to become Biologists or take up Biology related careers in the future to take these four factors into consideration.

Keywords: Exploratory Analysis, Students Scores

INTRODUCTION

The development of any nation is hinged on solid educational foundation for its citizenry. This suggests that education is a means of effecting changes in the society in order to build a well-developed country. The objective of education includes creativity, objectivity and intellectual adventure. Education enables a child to develop physically, mentally, socially, emotionally and intellectually. Education is the key to creating a society, which is dynamic and productive, offering opportunity and fairness to all. Therefore, it is axiomatic that efforts should be geared towards maintaining high standards in schools. The standards will be reflected in students' academic achievement.

School, colleges and universities have no worth without students. Students are most essential asset for any educational institute. The social and economic development of the country is directly linked with student academic performance. The students' performance (academic achievement) plays an important role in producing the best quality graduates who will become great leader and manpower for the country thus responsible for the country's economic and social development (Ali et. al, 2009). The performance of students in any academic task has always been of special interest to educators, parents 'and society at large. The primary concern of any educator who is entrusted with the responsibility of selecting students for any advance training programme in a given field is the ability to estimate as accurately and as early as possible the probability that such candidates will succeed or fail. The major obstacle to the development of education in Nigeria is persistent poor academic performance of students.

Many persons seem to be perplexed as to what factors are actually responsible for the fall in the standard of students' achievement in universities in Nigeria.

This puzzled state has eventually led many to attribute the abysmal fall in achievement to: poor condition of service for lecturers; inadequate supply of facilities and equipment; lack of motivation; wrong method of teaching and admission of incompetent candidates into

universities (Emaikwu & Nworgu, 2005). Onah (2012) and Emaikwu (2012) affirmed that the fall in standard of achievement by students at all levels of education has been awfully reported and acknowledged by all and sundry in Nigeria.

Intelligence is not the only determinant of the academic performance of the student. Academic performance of a student is always associated with many components of learning environment. It is worth noting that students' academic achievement is affected by numerous factors including sex, age, mode of entry and school factors.

The school is a social and learning agent that provides the environment upon which a child may be formally educated in order to attain educational goals.

Human beings, have unlimited capacity to learn, but may however be limited by the behavior patterns and facilities that the immediate environment offers.

According to Umoh (2006), nature only provides the raw materials in form of potentials, but it is the environment that determines the extent of development.

In furtherance to the menace of low academic performance which had been on the high strain in the Nigerian academic system and cannot be over emphasized as it had eaten deep into the quality of students and eventual leaders produced into the Nigerian economy. It' could be deduced that there exist a vacuum in the quality of students produced and the required quality of individual for various institutional need of the country.

Statement of the Problem

The public opinion about the appalling standard of performance of students graduating from universities in Nigeria in the recent time has reached an alarming crescendo. More disturbing is the common observation that many graduates from universities are being rejected by the labor market because of low academic competence. In accessing the cause effect of the level of student academic performance, the researcher consider some variables of the school as those instruments that could tailor the level of student academic performance.

The variables, which include age, sex, school and mode of entry is deem fit to affect students' academic achievement. Hence, the school variables remains an important area that should be studied and well managed to enhance students' academic performance.

In recent times, as in the past, the difficulties of certain concepts and students' performance have continued to be some of the subsisting issues in the teaching and

learning process. A review of the West African Examination Council (WAEC) Chief Examiners Report in Biology for the May/June and November/December Examinations in the last decade yields an insight into the direness of the situation. Remarks such as "students' poor understanding of certain biological terms", "non-familiarities with concepts of biology", "poor performance on questions related to biology" are among many others used by the WAEC Chief Examiner's in-charge of Biology to describe the weakness of students in Biology examinations (WAEC 2009 - 2013). The perennially poor and fluctuating performance of students in Biology is a recurrent theme in the same document. Failures in Biology, means a general shortage of manpower in related fields like Medicine, Agriculture, Industry (Samikwo, 2013) and education. This picture is even more depressing when viewed against the backdrop that Biology is the third most registered for subject (after English Language and Mathematics) in the May/June WAEC examinations (WAEC, 2009 - 2013).

The issue of poor academic -performance of students in Nigeria has been of much concern to the government, parents, teachers and even student themselves. The quality of education not only depends on the teachers as reflected in the performance of their duties, but also in the effective coordination of the school variables. It is believed that physical features have a form of relationship with the students' academic performance in terms of the age, sex, school and mode of entry.

Students' academic performance measurement has received considerable attention in previous research, it is challenging aspects of academic literature, and science student performance are affected due to social, psychological, economic, environmental and personal factors. These factors strongly influence on the students' performance, but these factors vary from person to person and country to country. Previously, most studies of student academic performance used the GPA to measure the student performance (Galiher, 2006; Darling, 2005; Broh, 2000; Stephen & Schaban, 2002).

They used GPA to measure students' performance in particular semester.

This research therefore, is motivated by the problem poor academic performance of students poses to the quality of students graduating from universities in Nigeria and as such intends to find out the effect of sex, age, school and mode of entry on academic performance of students using univariate analysis of variance, case study of Biology Students Federal University Wukari.

Aim and Objectives of the Study

For every human effort in trying to achieve a goal, there is always a purpose to serve. The aim of the study is to examine 'The Effect of Sex, Age, School and Mode of Entry on Academic Performance of Students using Univariate analysis of variance, case study of Biology Students, Federal University Wukari (FUW).

The Objectives of the study are:

1. To determine if sex, age, school attended and mode of entry into the University individually affect the students' scores in Biology.
2. To determine if the possible combine effect of the factors affect _the students' scores in Biology.

Research Questions.

The following questions guided this study;

1. To what extent does sex affect academic performance?
2. To What extent does age affect academic performance?
3. To what extent does school affect academic performance?
4. To What extent does mode of entry affect academic performance'?

Research Hypotheses

The study is intended to investigate the effect of sex, age, school and mode of entry on students' academic performance, therefore, data collected shall be used in testing the following hypotheses:

H01: There is no significant effect of sex on academic performance;

H02: There is no significant effect of age on academic performance;

H03: There is no significant effect of school on academic performance;

H04: There is no significant effect of mode of entry on academic performance.

Significance of the Study

The study is highly significant in enabling parents, educationist and educational stakeholders in measuring the effect of these variables on students' academic performance.

The findings will enable the government to look into these criteria — sex, age, school and mode of entry — at the point of admission so as to be guided in their resolutions.

The findings of this study will help determine the relationship between these variables and student academic performance and also this study will be of benefit to educationists who are interested in knowing how non classroom factors/variables affect students' academic performance.

This study is also germane to parents who are interested in the educational performance of their children most especially in Biology and parents who are tending to mold their children to become Biologists or to take up Biology related careers in the future.

Also, this study will be of immense contribution to existing literatures and motivate other researchers who may be interested in carrying out further researches in this regard.

Scope of the Study

The study will be conducted Federal University Wukari in Taraba State. The variables to be covered in this study include sex, age, school and mode of entry. This study is aimed at investigating the effect of the aforementioned nvariables on the academic performance of students in Biology using Generalized Linear Model. This study is also limited to the identified variables used in the study.

Limitations of the Study

The major constraints of this study include the conservative nature of organizations and their apathy towards providing information, especially with respect to their internal operation policies. As in all research efforts of this nature, time and finance was also a major constraint.

Definition of Terms

The following terms have been used in the course of this research work and as such need to be explained.

Sex

Sex in this context refer to gender that is the state of being male or female (typically used with reference to social and cultural differences rather than biological ones).

Age

Age in this context typifies the length of time a person has lived or a thing has existed.

School

It simply means an institution for educating children. In this context a higher institution of learning is being considered.

Mode of Entry

This simply means the mode of admission into the school. This could either be through J AMB, Direct Entry or Remedial Studies.

Analysis of variance (ANOVA)

This is used to uncover the main and interaction effects of categorical independent variables (called "factors") on an interval dependent variable. The new general linear model (GLM) implementation of ANOVA also supports categorical dependents. A "main effect" is the direct effect of an independent variable on the dependent variable. An "interaction effect" is the joint effect of two or more independent variables on the dependent variable. Whereas regression models cannot handle interaction unless explicit cross product interaction terms are added, ANOVA uncovers interaction effects on a built-in basis.

Observed Power

Is an estimate of the power of a study based on the observed effect size in a study. It is therefore not power that is being observed, but the effect size that is being observed. However, because the other parameters that are needed to compute power are known (sample size, significance criterion), the observed effect size is the only parameter that needs to be observed to estimate power.

However, it is important to realize that observed power does not mean that power was actually observed. Observed power is still an estimate based on an observed effect size because power depends on the effect size in the population (which remains unobserved) and the observed effect size in a sample is just an estimate of the population effect size.

Partial eta squared

Partial eta squared is the default effect size measure reported in several ANOVA procedures in SPSS.

Factor

A factor is an independent variable of interest in analysis of variance. E.g. curling time of hair cream.

Factor Level

A factor level is a category of a factor. Several categories makes up factor levels e.g. each hair cream being tested for curling time correspond to a factor level.

Treatment

A treatment is a particular-outcome of a factor. In one way ANOVA, a treatment corresponds to a factor level. In a two Way ANOVA, combination of any ywo factor corresponds to a treatment

METHODOLOGY

Introduction

Osuala (1985) defined research methodology as "the process of arriving at dependable solution to problems through planned and systematic collection, analysis and interpretation of data." He Went further to state that "it deals with how the researcher got its information, types and methods used for collection."

Hornby (2000), defined Research Methodology as "an act of study and investigation especially to discover new facts.

The hallmark of this chapter therefore, is to discuss or show Research Design,

Area of the Study, Population of the Study, Sample size and Sampling technique, Instrument of Data Collection, Validity and Reliability of the instrument and Method of Data Analysis.

Research Design

Research Design is the basic plan that guides the data collection, and analysis phrase of any research Work. Research design therefore, is regarded as the frame work Which specifies the type of information to be garnered including the source of data and the procedure used in collecting data.

According to Adefila (2008), Research Design is "the plan, structure and strategy of the study in view which enables the researcher to obtain the

required answers to the research questions as Well as putting all the variables under control.

Kerlinger (1973), also defined research design as the plan, structure and strategy of investigation conceived to answer research questions as variably, accurately and economically as possible, this research design sets up the framework for adequate test of relation among variables. The case study approach which is adopted in this project work involves the study of a specific set which in this case are Biology students, Federal University Wukari.

For the purpose of carrying out a good analysis and reaching a reasonable conclusion, data are being collected from various sources through the primary and secondary sources, i.e. using questionnaire and secondary data.

Area of Study

The study shall be carried out among Biology Students of Federal University Wukari, Taraba State. The Federal University Wukari, is one of the nine (9)

Federal Universities created by the Jonathan-led administration in 2011.

Federal University Wukari is located in Wukari town in Wukari Local Government Area of Taraba State. Wukari town is the major town in Wukari local government and the most educationally and socially developed. The town accommodates various ethnic groups among which are: the indigenous Jukuns, the Tivs, the Kutebs, the Hausas, the Ibos and the Yorubas. Wukari town occupies an area of 4, 308_kilometre square and populated with 241, 54-6 people according to 2006 census. Many schools are established within the town. At the primary level, there are 8 missionary schools, 8 government owned and 49 private schools. There are 10 governments owned secondary schools, 12 private owned secondary schools and l missionary secondary school (Education Office Wukari, 2012). Two major tertiary institutions exist in the town, 1 private-owned and one government'owned. The town also has a center for the National Teachers' Institute (NT I) distant learning programme. Indeed, the town is blessed with various schools, but sad enough it is still one of the major towns in a state regarded as educationally disadvantaged (Iyekekpolor, 2008). Geographically, the town is bounded by Ibi, a developing town in the west, Takum town in

the East, Gassol town in the North and Ukum Local Government of Benue State in the South. It is glaring that the town has little or no competing and challenging environment to make it rise high academically.

Population of the Study

According to Polit and Hungler (1999), "population is an aggregate or totality of all the objects, subjects or members that conform to a set of specifications.

The study population comprised of one hundred and fifty (150) students of Departments of Biology. However it is practically impossible to interview and administer questionnaires on the entire students as a result of time and financial constraints thus, a sample of 100 students representing 66.7% of the students was sample using simple random sampling. Due consideration was not given to equal representation of both sexes. Hence, it is believed that the selected sample and the resources there from adequately represent the position of the entire population.

Sample Size Determination

A sample is a subset of a population selected to participatein the study, it is a fraction of the Whole, selected to participate in the research project (Brink

1996; Polit & Hungler 1999). Sampling method on the other hand is the process of selecting a portion of the population to represent the entire population (Loblondo-Wood and Haber 1998; Polit&Hungler 1999).

The sample size that was used to represent the whole population was determined using Simple Random Sampling.

Sampling Technique

The sample technique adopted for this study is Judgmental Sampling Technique. The respondents for the research Were selected from the l50 students that make up the population of the study. A sample of 100 students representing 66.7% of the students was sampled using simple random sampling. Due consideration was not given to equal representation of both sexes. Hence, it is believed that the selected sample and the resources there from adequately represent the position of the entire population.

Sources of Data

Polit and Hungler (1999) defined data as information obtained in a course of a study.

The data used for this research Work were collected mainly from both primary and secondary sources.

Primary source: The primary data used for this Work were gotten through questionnaires which were administered to the respondents.

Secondary Source: The secondary data was gotten from textbooks, journals, newspapers, magazines and bulletin.

Instrument of Data Collection

The instrument used for the purpose of the study questionnaires. The questionnaire issued contains certain questions which are in accordance with the research work and the research hypotheses and are framed in a Way that it would not be misunderstood by the respondent.

Validity and Reliability of Instrument

Validity is defined as a measure of truth or falsity of the data obtained through using research instrument. It is classified as internal and external validity of the measuring instrument (Burns and Grove 2001). Reliability is the degree to which an assessment tool produces stable and consistent result (De Vos, 1998). The question issued to the respondents for this research work was designed in a way that it aroused interest in the mind of the respondents. The Questionnaire was issued out to prominent lecturers, professors and statisticians in the University who went through them and made necessary suggestions.

Method of Data Analysis

T-test for two independent sample

The independent sample T-test is the most suitable statistical tool for analyzing and comparing the means of two separate groups when the population variance

σ_1^2 and σ_2^2 are unknown.

Formulars for two sample T test

Case1: The case when $\sigma_1^2 = \sigma_2^2$ and are unknown

$$T = \frac{\bar{y}_1 - \bar{y}_2}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}$$

Where , $\bar{y}_1$ and $\bar{y}_2$ are the sample means, n_1 and n_2 are the sample sizes, $S_p{}^2$ is an estimate of the common variance $\sigma_1^2 = \sigma_2^2 = \sigma^2$ computed from $S_p{}^2 = \frac{(n_1-1)S_1^2 + (n_2-1)S^2{}_2}{n_1+n_2-2}$, and $S_1^2 = \frac{\sum_{i=1}^{n_1}(x_{1i}-\bar{x}_1)^2}{n_1-1}$ and $S_2^2 = \frac{\sum_{i=1}^{n_2}(x_{2i}-\bar{x}_2)^2}{n_2-1}$ are two individual sample variances.

Case2: The case when $\sigma_1^2 \neq \sigma_2^2$ and are unknown

$$T = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

This statistic is distributed approximately to Student T distribution when

$$v = \frac{(\frac{1}{n_1}+\frac{1}{n_2})^2}{\frac{\left(\frac{S_1^2}{n_1}\right)}{n_1-1} + \frac{\left(\frac{S_2^2}{n_2}\right)}{n_2-1}}$$

2^4 Factorial design

Factorial designs are used in the study of the effects of two or more factors, including all the possible combinations of the level of the factors that makes-up the treatments.

Here, we focus on the effects of sex (factorA), age(factor B), type of school attended(factor C) and mode of entry(factorD) on the score of students using statistical package and tools. Each factor exist at two levels.

The model for 2^4 factorial design.

The model for the experiment is:

$$Y_{ijkl} = \mu + \tau_i + \beta_j + \emptyset_k + (\tau\beta)_{ij} + (\tau\gamma)_{ik} + (\tau\emptyset)_{il} + (\beta\gamma)_{jl} + (\beta\emptyset)_{jl} + (\tau\beta\gamma)_{ijk} + (\tau\beta\emptyset)_{ijk} + (\tau\beta\gamma)_{ijk} + (\tau\beta\emptyset)_{ijl} + (\tau\beta\emptyset)_{ijl} + (\tau\gamma\emptyset)_{ikl} + (\tau\beta\gamma\emptyset)_{ijkl} + e_{ijkl}$$

Where :

i =1,…,a

j =1,…,b

k =1,…,c

l =1,…,d

Y_{ijkl} = The response variable

μ= The mean response or over-all mean

τ_i =FactorA, β_j=factorB, γ_k =factorC, $\emptyset_l$=factor D

$(\tau\beta)_{ij}$=Interaction effect between factorA and factorB

$(\tau\gamma)_{ik}$ =Interaction effect between factorA and factorC

$(\tau\emptyset)_{il}$ =Interaction effect between factorA and factorD

$(\beta\gamma)_{jk}$=Interaction effect between factorB and factor C

$(\beta\emptyset)_{jl}$=Interaction effect between factorB and factorD

$(\gamma\emptyset)_{kl}$=Interaction effect between factorC and factorD

$(\tau\beta\gamma)_{ijk}$ =The three factor interaction effect of ABC

$(\tau\beta\emptyset)_{ijl}$=The three factor interaction effect ofABD

$(\beta\gamma\emptyset)_{jkl}$=The three factor interaction effect of BCD

$(\tau\gamma\emptyset)_{ikl}$=The three factor interaction effect of ACD

$(\tau\beta\gamma\emptyset)_{ijkl}$=The four factor interaction effect of ABCD

e_{ijkl}= The error term

Assumptions

1. Your dependent variable should be measured at the continuous level (i.e. it is an interval or ratio variable).
2. Your independent variables should each consist of two or more categorical, independent groups,
3. You should have independence of your observations
4. There should be no significant outliers
5. Your dependent variable should be approximately normally distributed for each combination of the groups of the independent variables.

6. There needs to be homogeneity of variances for each combination of the groups of the independent variables,
7. The error term is normally and identically distributed with mean zero and constant variance σ^2 i.e $e_{ijkl} \sim N(0, \sigma^2)$,
8. The rows and columns effective are additive
9. The effect of the ith row is summed upto zero. i.e $\sum \tau_i = 0$
10. The effect of the jth column is summed upto zero i.e. $\sum \beta_j = 0$
11. The summation of the residual term is equalto zero.

2.9.3 Sum of Square Identity for 2^4 Factorial Design

The theorem(The sum of square identity)

$$SSS = \sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{c}\sum_{i=1}^{d} Y_{ijkl} - \frac{(Y...)^2}{abcdr}$$

where

$$\frac{(Y_{....})^2}{abcdr} \quad = \text{Correction factor(C.F.)}$$

a,b,c and d are levels of factorA, factorB, factorC, and factorD

$$SSA = \frac{\sum_{i=1}^{a} Y_{ijkl}^{\ 2}}{bcdr} - C.F$$

$$SSB = \frac{\sum Y_{ijkl}^{\ 2}}{acdr} - C.F$$

$$SSC = \frac{\sum_{j=1}^{c} Y_{ijkl}^{\ 2}}{abdr} - C.F.$$

$$SSD = \frac{\sum_{l=1}^{d} Y_{ijkl}^{\ 2}}{abcdr} - C.F$$

Sum of Squares of 2-Factor Interactions

$$SSAC = \frac{\sum\sum Y_{ijkl}^{\ 2}}{bdr} - C.F$$

$$SSBC = \frac{\sum\sum Y_{ijkl}^{\ 2}}{adr} - C.F$$

$$SSAB = \frac{\sum_{i=1}^{a}\sum_{j=1}^{b} Y_{ijkl}^{2}}{cdr} - C.F$$

$$SSAD = \frac{\sum_{i=1}^{a}\sum_{j=1}^{b} Y_{ijkl}^{2}}{bcr} - C.F$$

$$SSBD = \frac{\sum_{i=1}^{b}\sum_{l=1}^{d} Y_{ijkl}^{2}}{ar} - C.F.$$

$$SSCD = \frac{\sum_{k=1}^{c}\sum_{l=1}^{d} Y_{ijkl}^{2}}{abr} - C.F.$$

2.9.5 Sum of Square of 3-Factor Interactions

$$SSABC = \frac{\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{c} Y_{ijkl}^{2}}{dr} - C.F.$$

$$SSABD = \frac{\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{l=1}^{d} Y_{ijkl}^{2}}{cr} - C.F.$$

$$SSACD = \frac{\sum_{i=1}^{a}\sum_{k=1}^{c}\sum_{l=1}^{d} Y_{ijkl}^{2}}{br} - C.F.$$

$$SSBCD = \frac{\sum_{j=1}^{b}\sum_{k=1}^{c}\sum_{l=1}^{d} Y_{ijkl}^{2}}{ar} - C.F.$$

Sum of Squares of 4-Factor Interaction

$$SSABCD = \frac{\sum_{i=1}^{a}\sum_{j=1}^{b}\sum_{k=1}^{c}\sum_{l=1}^{d} Y_{ijkl}^{2}}{r} - C.F.$$

Sum of Squares of Errors

SSE=SST-SSA-SSB-SSC-SSD-SSAB-SSAC-SSAD-SSBC-SSBD-SSCD-SSABC-SSABD-SSACD-SSB

3.9.8 Mean Squares

$$MSA = \frac{SSA}{a-1}$$

$$MSB = \frac{SSB}{b-1}$$

$$MSC = \frac{SSC}{c-1}$$

$$MSD = \frac{SSD}{d-1}$$

$$MSAB = \frac{SSAB}{(a-1)(b-1)}$$

$$MSAC = \frac{SSAC}{(a-1)(c-1)}$$

$$MSCD = \frac{SSCD}{(c-1)(d-1)}$$

$$MSBC = \frac{SSBC}{(a-1)(d-1)}$$

$$MSAD = \frac{SSAD}{(a-1)(d-1)}$$

$$MSABC = \frac{SSABC}{(a-1)(b-1)(c-1)}$$

$$MSABD = \frac{SSABD}{(a-1)(b-1)(c-1)}$$

$$MSACD = \frac{SSACD}{(a-1)(c-1)(d-1)}$$

$$MSBCD = \frac{SSBCD}{(b-1)(c-1)(d-1)}$$

$$MSABCD = \frac{SSABCD}{(a-1)(b-1)(c-1)(d-1)}$$

$$MSE = \frac{SSE}{abcd(r-1)}$$

Hypothesis:

i. H_{01}: None of the main factors have significant effect on scores

H_{11}: At least one of the main factors have significant effect on scores

$\alpha = 0.05$

ii. H_{02}: None of interaction factors have significant effect on scores

H_{12}: At least one of interaction factors have significant effect on scores

Anova Table for 2^4 Factorial Design

SOURCE OF VARIATION	DEGREE OF FREEDOM	SUM OF SQUARE	MEAN SQUARE
A	(a-1)	SSA	MSA= $\frac{SSA}{a-1}$
B	(b-1)	SSB	MSB= $\frac{SSB}{b-1}$
AB	(a-1)(b-1)	SSAB	MSAB= $\frac{SSAB}{(a-1)(b-1)}$
C	(c-1)	SSC	MSC= $\frac{SSC}{(c-1)}$
AC	(a-1)(c-1)	SSAC	MSAC= $\frac{SSAC}{(a-1)(c-1)}$
BC	(b-1)(c-1)	SSBC	MSBC= $\frac{SSBC}{(b-1)(c-1)}$
ABC	(a-1)(b-1)(c-1)	SSABC	MSABC= $\frac{SSABC}{(a-1)(b-1)(c-1)}$
D	(d-1)	SSD	MSD= $\frac{SSD}{(d-1)}$

AD	(a-1)(d-1)	SSAD	MSAD= $\frac{SSAD}{(a-1)(d-1)}$
BD	(b-1)(d-1)	SSBD	MSBD= $\frac{SSBD}{(b-1)(d-1)}$
ABD	(a-1)(b-1)(d-1)	SSABD	MSABD= $\frac{SSABD}{(a-1)(b-1)(d-1)}$
CD	(c-1)(d-1)	SSCD	MSCD= $\frac{SSCD}{(c-1)(d-1)}$
ACD	(a-1)(c-1)(d-1)	SSACD	MSACD= $\frac{SSACD}{(a-1)(c-1)(d-1)}$
BCD	(b-1)(c-1)(d-1)	SSBCD	MSBCD= $\frac{SSBCD}{(b-1)(c-1)(d-1)}$
ABCD	(a-1)(b-1)(c-1)(d-1)	SSABCD	MSABCD= $\frac{SSABCD}{(a-1)(b-1)(c-1)(d-1)}$
Error	abcd(n-1)	SSE	MSE= $\frac{SSE}{abcd(n-1)}$
Total	abcdn-1	SST	MST= $\frac{SST}{abcdn-1}$

Test Statistics: P-value from ANOVA table

Decision: (i) Reject H01 if P-value < level of significance($\alpha = 0.05$)

(ii) Reject H02 if P-value < level of significance($\alpha = 0.05$)

Important Points about Factorial Design

An interaction effect between two factors can be measured only if the two factors are tested together in the same experiment.

When interaction is absent, the simple effect of a factor is the same for all levels of the other factors and equal to the main effect.

When interaction is present, the simple effect of a factor changes as the levels of the other factors changes and consequently the main effect is different from the simple effect. This when interaction effect is significant, emphasis should be on simple effect.

Advantages of Factorial Design

Factorial experiments are widely used in exploration or preliminary investigation where not much is known about how different factors affect variables of interest, hence they are useful in quick determination of the effect of each number or factor.

When the experimenter is interested in interaction between factors, factorial experiment can be used.

When there is no interaction-between factors factorial experiment is still very economical

Because of the use of several factors in factorial experiments, recommendations can be made over a Wide range of conditions.

Disadvantages of Factorial Design

If the objective of the investigation is specialized, it may be more profitable to conduct intensive work on a single factor rather than factorial.

If the factors to be investigated are numerous, the size and complexity of the experiment becomes a problem.

Because of the various possible treatment comparisons, the results of the factorial experiment involving many factors become difficult to interpret.

RESULTS

Introduction

This chapter contains test for normality in the dependent variable, and independent "sample T-test, Univariate analysis for the 2^4 factorial design, partial eta squared, noncent parameter, observed power, and graphical test for assumption of the model. The test for normality in the dependent variable is necessary to be carried out so as to be sure that the assumption for normality which is a characteristic of all parametric tests is valid, otherwise, a different approach of analyzing data will have to be sought for. It is also very important to determine that the other relevant assumptions for the 24 factorial model are not violated so as to be sure that the Univariate result is not spurious.

Testing for Normality in the Dependent Variable

The dependent variable is the scores of students in the subject Biology. We employed histogram with _normal curve, normal probability plot and Kolmogorov Smirnov Test to

determine the normality of the dependent variable. Figure 4.1 shows the histogram with normal curve. We can see that the distribution is approximately normal. Figure 4.2 shows the normality probability plot. The points lie very closely to the center line from at the middle and then a little away at the tail ends. Here we can see that there is no serious reason to suspect that the data deviates from normality. The Anderson Darling test statistic value is 0.610 and the corresponding p-value is 0.110.

Since this p-value is not less than 0.05 level of significance, we can conclude that the distribution of students' scores is normally distributed.

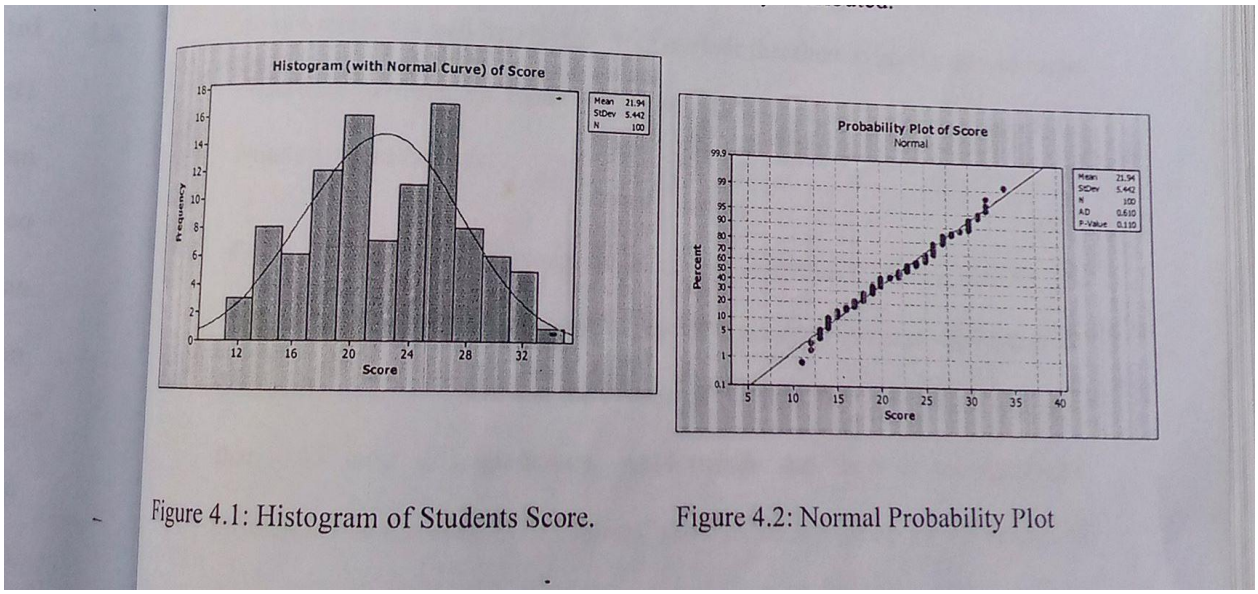


Figure 4.1: Histogram of Students Score.

Figure 4.2: Normal Probability Plot

All these tests have shown that the dependent variable, students' scores have not violated the assumption of normality, so we can apply the two independent sample T-test and Univariate analysis for 2^4 factorial designs.

Testing for the significance of main effects

T-test statistic is employed in testing for the significance of main effect since each of the factors considered in the research exist at two levels.

From Appendix 1, the group statistic and independents samples test for the factor sex is shown. The Levene's test for equality of variances shows that the

F-statistic value is 2.116 and the P-value is 0.149. Since the P-value is greater than 0.05 level of significance, there is no significant difference in the variances of male and female students' scores. So, equality of variances is assumed. Testing for the equality of means, the

testing value is 0.890 and the P-value is 0.376. Since the P-value is greater than 0.05 level of significance, We do not reject the null hypothesis. We conclude that there is no significant mean difference between the mean of the male students' scores and the mean of the female students scores. –

From Appendix 2, the group statistics and independent sample test for the factor Age is shown. The Levene's Test for equality of variance shows that the

F-statistic value is 1.642 and the P-value is 0.203. Since the P-value is greater than 0.05 level of significance, We conclude that there is no significant difference in the variances of students' score in the age group 15 — 20years and above 20years. Equality of variance is assumed. Testing for the equality of mean, the T-test value is -0.55 8 and the P-value is 0.578. Since the P-value is greater than 0.05 level of significance, we do not reject HO. We conclude that there is no significant mean difference in the score of students between the age group 15 — 20years and above 20years.

Appendix 3 shown the group statistic and the independent samples test for type of school attended. The Levene's test for equality of variance shows that the F- statistic value is 0.820 and the P-value is 0.367. Since the P-value is greater than 0.05 level of significance, we concluded that there is no significant difference in the variances of the students' scores between day school and boarding school. Testing for equality of mean, the T-test value is -2.063 and the P-value is 0.042. Since the P-value is less than 0.05 level of significance.

We reject the HO and conclude that the mean score Boarding students is significantly greater than the mean score of Day students.

Appendix 4 shown the group statistic and the independent samples test for

UTME and DE mode of entry into the University. The Levene's test for equality of variance shows that the F-statistic value is 0.007 and the P-value is

0.934. Since the P-value is greater than 0.05 level of significance, we concluded that there is equality in the variances of the students' scores who came in through UTME and those who came in through DE. So we assumed equal variances in the scores of the two groups. Testing for equality of means, the T-test statistic value is 1.047 and corresponding P-value is 0.054. Though the P-value is almost equal or falling in to the region of less than 0.05, but we will still not reject H0 since the P-value is greater in value than 0.05 level of significance. We concluded that the mean score of students who came into the

University through UTME is not significantly different from the mean score of students who came through the DE.

From Appendix 6 the marginal estimated mean table shows that the mean

(29.00) for the treatment combination female, above 20years, day school, and

DE has the highest effect. Next is the mean effect (25 .330) for the treatment combination female above 20years, boarding school and UTME. Next is the mean effect (24.66) for the treatment combination male, above 20years, boarding and DE

The least mean effect (l5.400) is that of the treatment combination female, l5-20years, day school and DE. This is followed by the mean effect (17.00) for the treatment combination male, 15-20years, boarding school and DE.

This is also followed by the mean effect (17.33 for the treatment combination male, l5-20 years, day school and DE.

Testing for Significance of Effects of all possible Interactions

Here we employed the Univariate 2^4 factorial analyses to analyzed the data.

Table4.3 shows Tests of between-subjects effects. It shows the analysis of variance containing the mode l fitness, sex as a factor, age as a factor, school as a factor, mode of entry as a factor, sex and age as an interaction, sex and school

as an interaction, sex and entry as an interaction, age and school as an interaction, age and entry as an interaction, school and entry as an interaction, sex, age and school as an interaction, sex, age and entry as an interaction; sex, school and entry as an interaction; age, school and entry as an interaction; sex, age, school and entry as an interaction. The various sums of squares, degrees of freedom, Mean squares, F statistic values and corresponding p-value are shown. The model's p-value (=0.000) is less than 0.05 level of significance.

This implies that the model fits and the R square adjusted value showed that

94.7% of the factors and their interactions explained the scores of students. The p-value of the factor sex (0.506) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the sex of the students has no significant effect on the scores. The p-value of age (=0.064) is not less than

0.05 level of significance, so We do not reject the null hypothesis which states that the age of the students has no significant effect on the scores. The p-value of school (0.506) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the school of the students has no significant effect on the scores. The p-value of entry (0.157) is not less than

0.05 level of significance, so we do not reject the null hypothesis which states that the mode of entry of the students has no significant effect on the scores.

The p-value of interaction sex and age (0.933) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the sex and age of the students has no significant effect on the scores. The p-value of interaction sex and school (0.970) is not less than 0.05 level of significance, so

We do not reject the null hypothesis which states that the sex and school of the students has no significant effect on the scores. The p-value of interaction sex and entry (0.564) is not less than 0.05 level of significance, so We do not reject the null hypothesis which states that the sex and entry of the students has no significant effect on the scores. The p-value of interaction age and school

(0.408) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the age and school of the students has no significant effect on the scores. The p-value of interaction age and entry (0.074) is not less than 0.05 level_ of significance, so we do not reject the null hypothesis which states that the age and entry of the students has no significant effect on the scores. The p-value of interaction school and entry (0.268) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the school and entry of the students has no significant effect on the scores. The p-value of interaction sex, age and school (0.250) is not less than 0.05 level of significance, so We do not reject the null hypothesis which states that the sex, age and school of the students has no significant effect on the scores. The p-value of interaction sex, age and entry (0.941) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the sex, age and entry of the students has no significant effect on the scores. The p-value of interaction sex, school and entry (0.139) is not less than 0.05 level of significance, so we do not reject the null hypothesis which states that the sex, school and entry of the students has no significant effect on the scores. The p-value of interaction age, school and entry (0.268) is not less than 0.05 level of significance, so we do

not reject the null hypothesis which states that the age, school and entry of the students has no significant effect on the scores. The p-value of interaction sex, age, school and entry (0.039) is less than 0.05 level of significance, so We reject the null hypothesis which states that the sex, age and school of the students has no significant effect on the scores. The interaction effect of the four factors is significant.

Table 4.3 Tests of Between-Subjects Effects

Dependent Variable: Score

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Model	48773.444[a]	16	3048.340	111.595	.000	.955	1785.517	1.000
Sex	.482	1	.482	.018	.895	.000	.018	.052
Age	96.379	1	96.379	3.528	.064	.040	3.528	.459
School	12.207	1	12.207	.447	.506	.005	.447	.101
Entry	55.581	1	55.581	2.035	.157	.024	2.035	.292
Sex * Age	.196	1	.196	.007	.933	.000	.007	.051
Sex * School	.039	1	.039	.001	.970	.000	.001	.050
Sex * Entry	9.141	1	9.141	.335	.564	.004	.335	.088
Age * School	18.888	1	18.888	.691	.408	.008	.691	.130
Age * Entry	89.187	1	89.187	3.265	.074	.037	3.265	.431
School * Entry	33.911	1	33.911	1.241	.268	.015	1.241	.196
Sex * Age * School	36.621	1	36.621	1.341	.250	.016	1.341	.208
Sex * Age * Entry	.149	1	.149	.005	.941	.000	.005	.051
Sex * School * Entry	61.041	1	61.041	2.235	.139	.026	2.235	.315
Age * School * Entry	33.922	1	33.922	1.242	.268	.015	1.242	.196
Sex * Age * School * Entry	119.616	1	119.616	4.379	.039	.050	4.379	.543
Error	2294.556	84	27.316					
Total	51068.000	100						

a. R Squared = .955 (Adjusted R Squared = .947)

b. Computed using alpha = .05

The Eta squared value for the four factors (sex, age, school and entry) interaction (0.050) showed the largest contribution to the variations in the students score in the model. Also

the four factors (sex, age, school and entry) interaction showed the largest value in Noncent parameter and likewise in the observed power. Next to it is age.

Since the analysis showed that the interaction sex, age, school and mode of entry is significant and contributes most to variation in the model, we will create a model containing just this four factors interaction.

Table 4.4 shows the four factors interaction Univariate analysis.

Tests of Between-Subjects Effects

Dependent Variable: Score

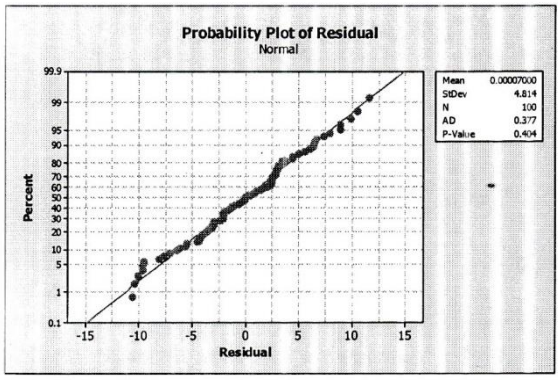
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[b]
Model	48773.444[a]	16	3048.340	111.595	.000	.955	1785.517	1.000
Sex * Age * School * Entry	48773.444	16	3048.340	111.595	.000	.955	1785.517	1.000
Error	2294.556	84	27.316					
Total	51068.000	100						

a. R Squared = .955 (Adjusted R Squared = .947)

b. Computed using alpha = .05

Testing for other Assumptions for Univariate 2^4 factorial model

We employed normal probability plot to test the residuals of the model to determine if they are normally distributed. Figure shows the Anderson Darling test statistic value (=0.377) and the corresponding p-value (=0.404). Since the p-value is not less than 0.05 level of significance, we conclude that the residual follows normal distributionf Figure shows the Kolmogorov Smirnov test statistic value (0.066) and the corresponding p-value (=0.150). Since the p-value is not less than 0.05 level of significance, we conclude that the residual follows normal distribution.



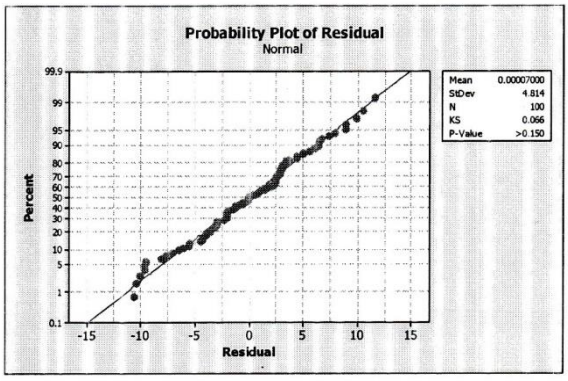


Figure: Anderson Residual Probability Plot Figure: Smirnov Residual ProbabilityPlot

To test the assumption of independency between the residuals and the predicted dependent variable, we employ the use of scatter plots. Figures and shows the scattered plots of residual against predicted dependent variable, and standardized residual against the predicted variable. Both figures do not showed a serious suspicious of dependency between the residuals and predicted students' scores.

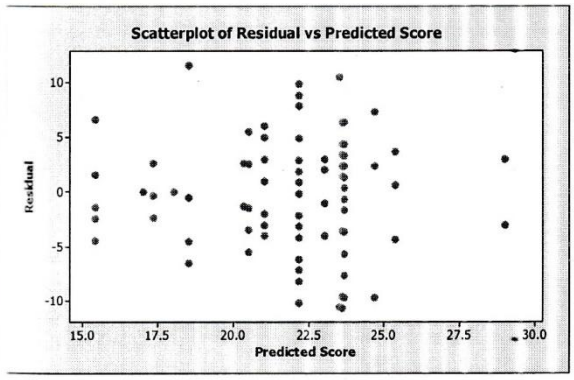


Figure: Residual Vs Predicted Scatter Plots.

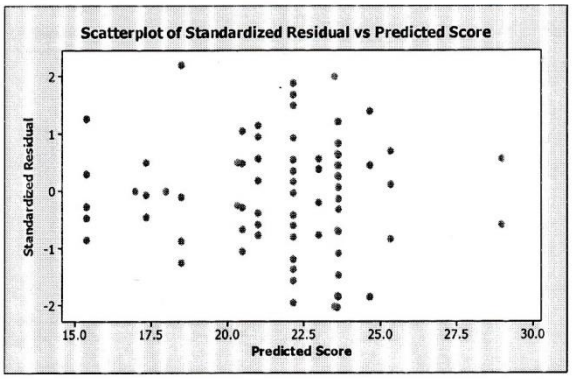


Figure: Z (Residual) Vs Predicted Scatter Plots.

Testing for independence and equality of variance among the residuals, we employ the use of Time Scattered Plots. Figure showed the time plots of the residual. The plot also showed no dependency among the residuals and no serious inequality in the residuals variance

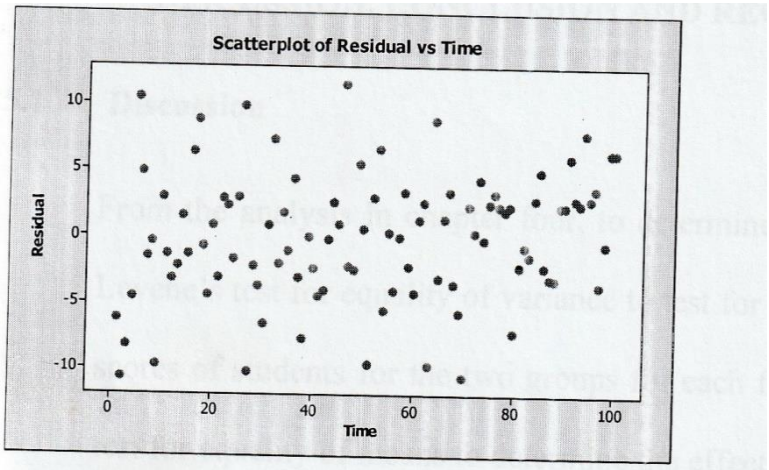


Figure: Scatter Plot of Residual Vs Time

DISCUSSION

From the analysis in chapter four, to determine the main effects, we employ Levene's test for equality of variance to test for homogeneity of variance in the scores of students for the two groups for each factor. And also, we employ T- test for equality of means to determine the effects of each factor.

There is equality of Variances for the two groups of each of the 4-factors. So, equality of variance is assumed. The T-test showed that there is no significant main effect of sex in the variation of the students' score. This is so since the mean scores of male students is not significantly different from the mean score of female students.

The T-test to determine the main effect of age is not also significant. It showed that there is no significant main-effect of Age in the variation of the students' score. Since the mean score of students in the age group (15-2O) years, is not significantly different from the mean score of students in the age group above 20yrs.

The T-test showed that there is significant main effect of school in the variation of the students score. This is so since the mean score of the students who attended day school is significantly less than the mean score of students who attended boarding school.

The T-test showed that there is no significant main effect of mode of entry in the variation of the students score. This is so since the mean score of UTME students is not significantly different from the mean score of DE students.

To determine the all possible combined effect of the interactions, we employed the Univariate Analysis for four factors each at two levels factorial design model. The Analysis showed that the combined effect of the 4 factors has significant effect on the variation of the students score. The Eta squared also showed that the largest contribution to the variations of the students score in the model is the combined 4-factors interaction. That is, the effect of the interaction sex, age, School attended and Mode of entry into the university together contribute greatly to the significant of the variation in the students score in Biology. From ***Appendix VI***, the marginal estimated mean table shows that the mean (29.00) for the treatment combination female, above 20years, day school, and DE has the highest effect. Next is the mean effect (25.330) for the treatment combination female above 20years, boarding school and UTME. Next is the mean effect (24.66) for the treatment combination male, above 20years, boarding and DE.

The least mean effect (l5.400) is that of the treatment combination female, 15-20years, day school and DE. This is followed by the mean effect (17.00) for the treatment combination male, 15-20years, boarding school and DE.

This is also followed by the mean effect (17.33) for the treatment combination male, 15-20 years, day school and DE.

The assumption for the T-test and the univariate are all satisfied. The students' scores is approximately normally distributed.

The residuals from the univariate 2^4 factorial model follow a normal distribution. The residuals are also independent from each other and independent from the explanatory variables, and predicted students score. The residuals showed equality in variance.

CONCLUSION

The main effect of school attended by a student is significant in the performance of the student in the subject Biology. Also the combined effect of sex, age, school attended and mode of entry into the University of a Student is significant in determining the performance of the student in Biology. If the student is a female above 20years old, attended a day school and entered the

University through Direct Entry, will perform the best in the course Biology. If the student is a female between the ages of l5years to 20years, attended a day school and entered the University through Direct entry, will perform the least in the course Biology.

Recommendations

The Researcher therefore recommended the following;

That parents and educationists should provide enabling environment for the students by ensuring their age, school and mode of entry is taken cognizance of as it has a significant impact on the students' performance.

Parents who-are interested in the educational performance of their children most especially in Biology and parents who are tending to mound their children to become Biologists or take up Biology related careers in the future to take these four factors into consideration.

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