The Place of Parametric Statistical Methods in Conducting Research in the Millennium Age.

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ABSTRACT

The act of conducting credible and reliable research should not be left in the hands of novice, incompetents, gamblers, or to guess work. Systematic, logical, and coherent approaches have to be highlighted and expatiated to beginners to sustain their growth into scholars who aspire to go deeper into their chosen fields. The culture of conducting universally acceptable research in all field of human endeavors should be jealously enhanced and maintained, if the processes of research as springboard upon which other developments (economic, social, educational, technological, administrative, environmental, scientific, etc.) is to be maintained. Collaborative efforts by all the stakeholders should be made to promote sustainable skills and knowledge in research works. This paper examines the place of parametric statistical methods with their multifarious characteristics in conducting research in the Millennium Age (21st Century). Efforts were made to clarify some pre-conditions necessary for the adoption of each of the methods highlighted. Workable recommendations were made to the various stakeholders as ways to concretize research.

(Keywords: research activity, research process, statistics, research design, statistical analysis, parametric statistics)

INTRODUCTION

Research as a concept has multifarious and multi-dimensional definitions to contend with. Various experts and scholars have used different parameters and yardsticks to explain the concept. Critical examinations of this varied definition have shown that individual definitions of research as a concept involves semantic clarification. However, some definitions are given below to itemize arrays of thoughts and perceptions.

Research can be defined as "a systematic, controlled, empirical, and critical investigation of hypothetical preposition about the presumed relation among natural phenomenon". In line with this, a popular dictionary definition of research is "systematic investigation towards increasing the sum of human knowledge".

In another dimension, research is defined as "the process of arriving at dependable solutions to problems through the planned and systematic collection, analysis and interpretation of data", Alli (1996), Osuala (2001).

Furthermore, spectrums of definition of research have been juxtaposed below.

1. Research is an endeavor to study or obtain knowledge through the use of a systematic approach with the intent of clarification.

2. Research is a curiosity-driven activity that has the purpose of discovery and advancement of knowledge (Basic Research).

3. Research is a systematic investigation including research development testing and evaluation, designed to develop or to contribute to generalizable knowledge.

4. Research is a form of enquiry that involves seeking of evidence to increase knowledge.

5. Research with experimental development is a creative work undertaken in a systematic basis in order to increase knowledge, including knowledge of humanity, culture and society and the use of this stock of knowledge to device new application. Fawole, I. Egbokhare, F.O. Ishola, O.A. Odejide, A.I and Olayinka, A.I. (2005).

Yet in another viewpoint, research is seen as "an active, diligent and systematic process of inquiry in order to discover, interpret, or revise facts, events, behaviors, or theories, or to make practical applications with the help of such facts, laws or theories". Olaewe (2006). Research is a scientific study to find out facts, test models and develop theories about the natural world.

Summarily, research as a concept and a process is "a systematic empirical, painstaking, orderly, controlled, experimental activity, inquiry, a search for knowledge, investigation, interpretation and application of scientific data, aimed at discovery of knowledge with a view to proffering solutions and reach new conclusions". Olaewe. (2006).

Research activity primarily involves the discovery of knowledge that was not previously known or understood, or the development of a new organization or structure of knowing materials that provide a new understanding about the subject matter. Any activity classified as research and experimental development is characterized by originality, it should have investigation as a primary objective and have the potential to produce results that are sufficiently general for humanity's stock of knowledge (theoretical and or practical) to be recognizably increased.

Research can be classified into the following with their distinctive characteristics and activities such as:

i. **Pure Basic Research:** Is experimental and theoretical work undertaken to acquire new knowledge without working for long term benefit other than the advancement of knowledge.

ii. **Strategic Basic Research:** Is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognized practical problems.

iii. **Applied Research:** Is original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or determine new ways of achieving some specific and predetermined objectives.

iv. **Experimental Development:** Is systematic work, existing knowledge gained from research or practical experience that is directed to producing new materials, products, systems, and services, or to improving substantially those already produced or installed.

v. **Ethnographic:** attempts to describe group behavior and interaction in social settings. It relies on qualitative techniques especially observation and careful recoding of events and social interaction.

vi. **Historical:** attempts to describe and explain conditions of the past. It generally relies on qualitative data such as written documents, archival records and oral histories.

vii. **Descriptive:** attempts to describe and explain conditions of the present. It relies on qualitative and quantitative data gathered from written documents, personal interviews, test results, surveys, etc.

viii. **Correlational:** attempts to explore relationships or make predictions. It relies on quantitative data such as test scores, grade point averages, attitudinal instruments etc. which can be correlated and shown that some relationship exists between two variables or among variables. The variables of interest can be mutually exclusive or opposite in nature for instance, rate of advertisement and reward of sales, death and birth, income and expenditure, immigration and emigration etc.

ix. **Action and Evaluation Research:** attempts to determine the value of a product, procedures, or program in a particular (e.g. school, district) setting with the goal of improving same. Action and evaluation does not attempt to generalize results for a broader population.

x. **Casual-Comparative:** attempts to explore cause and effect relationships where causes already exist and cannot be manipulated. It

relies on both qualitative and quantitative data such as written documents, interviews, test scores, etc.

xi. **Experimental:** attempts to explore cause and effect relationships where causes can be manipulated to produce different kinds of effects. It relies mostly on quantitative data such as test scores and measures of performance.

xii. **Survey Research:** Is the one in which a group of people or items is studied by collecting and analyzing data from only a few people or items considered to be representative of the entire group. Survey employs a variety of data gathering instruments or techniques such as the questionnaire, the interview, observations, Focus Group Discussion (FGD), tests, etc.

Characteristically, research is systematic, it increases some of human knowledge, and it should be relevant and universal in nature. It may equally lead to discovery. This implies that research ought to be well organized and executed within a system of ideas. The importance of a system of idea, or a discipline is of two fold. Preece (1998), argues that only a systematically trained mind is likely to be aware of the possible significance of any chance/observation from which the mind can deductively arrive at a logical and empirical conclusions.

The aim behind a research work may perhaps include discovery. In social sciences, humanities, and education, it appears over-ambitious, even daunting, to increase human knowledge in any systematic or universal way as to suggest discovery or anything near it. However, systems of knowledge are built up incrementally that is a single research project can hardly lead to discovery.

There are sequential steps in research; these orderly steps are known as the research process. The first step, which is not always obvious to a layman, is the identification and selection of a problem. The second step is the review of the related literature to establish the theoretical and conceptual framework. The researcher reviews books journals, magazines, theses, archival, documents, etc., that have relevance to the problem directly or indirectly or have treated the problem so as to ascertain what aspects of it need further clarification or investigation. The third stage the formulation of hypotheses or questions. The researcher hypothesizes about the relationship between the concepts identified in the problem.

The fourth step is the design construction. Research design is a data discipline; it is a blueprint of what to carry out in research. It specifies the formulation of a strategy to resolve a particular question. Research design highlights the collection and recording of the evidence gathered. It itemizes the processing and analysis of those data collected and eventual interpretation. It explains in detail the statistical/theoretical/conceptual power possessed by the researcher to exercise control on the data (e.g., randomization, matching or statistical). Through research design, the instruments to be used for data collection and its validation as well as its reliability coefficient would be determined. The nature of the data as well as the statistical methods to be employed would be indicated.

The last step in conducting research is the data analysis. The data collected in the preceding stage are subjected to the statistical analysis/rigors in order to answer the research questions earlier generated and test the hypotheses. This is one of the crucial stages where those clumsy date or senseless information would be decoded and assigned meanings that would give final interpretation to the outcomes of the research work. Based on the findings, the appropriate and logical conclusions and recommendations would be made.

THE NEED FOR STATISTICAL ANALYSIS IN RESEARCH

Statistics can be defined as “the Science and Practice of developing knowledge through the use of empirical data expressed in quantitative form. It is based on statistical theory which is a branch of applied mathematics”.

Statistics is the science of collecting, classifying, summarizing, and analyzing data. Data can be any set of information. Furthermore, statistics is seen as “a mathematical science pertaining to collection, analysis, interpretation, and presentation of data. It is applicable to a wide variety of academic disciplines from the physical

and social sciences to the humanities and educations as well as to business government and industry".

Given a collection of data, statistics may be employed to summarize or describe the data, this use is called descriptive statistics. Can the data be summarized in a careful way, either numerically or graphically, to yield insight about the population in question? Basic examples of numerical description include the mean and standard deviation. Graphical summarization includes various kinds of charts and graphs. In addition, patterns on the data may be modeled, in a way that accounts for randomness and uncertainty in the observations, this use is called inferential statistics. These inferences may take the form of answers to a Yes/No question (hypothesis testing), estimate of numerical characteristics (estimation), prediction of observations, description of association (correlation) or modeling of relationship (regression), ANOVA, time series, and data mining.

STATISTICAL ANALYSIS IN RESEARCH WORK

Statistical analysis is seen as "analyzing collected data for the purpose of summarizing information to make it more usable and/or making generalizations about a population based on a sample drawn from that population". It is the application of probability theory to quantify descriptive data. It is a way of using mathematical formula/formulae to make predictions. Statistical analysis involves computing test scores on a profile.

Statistical analysis refers to a method used to process large amounts and report overall trends. Statistical analysis is particularly useful when dealing with noisy data. Statistical analysis provides ways to objectively report on how unusual an event is based on historical data. The use of any statistical method is valid only when the system or population under consideration satisfies the basic.

Mathematical assumptions of the method or misuse of statistics can produce subtle but serious errors in description and interpretation-subtle in that even experienced professionals sometimes make such errors, and serious in that they may affect social policy, medical practice and the reliability of structures such as bridges and nuclear power plants.

PARAMETRIC STATISTICS

In making inferences about population based on the behavior of samples and in testing hypothesis, there are number of different methods or tests of significance which can be applied in research studies. Different tests of significance are appropriate for different sets of data. Factors such as the scale of measurement units, the data of groups, and the number of independent variables determine which test of significance should be selected for a given research design.

Parametric statistical methods of analyzing data are more robust with respect to violations of some their assumptions. That is, failure to have a perfectly normal distribution is really not damaging to the accuracy of the probability values obtained with the t-test or the analysis of variance (ANOVA). In fact, even rather substantial departures from normality have a relatively minor impact on the result of the test, especially if the sample size is large.

Similar statement could be made about the robustness of these techniques when group variances are not equal. Consequently, moderate violation of the assumptions of normality and homogeneity of variance are often not strong reasons for choosing a non parametric over parametric test.

Furthermore, parametric statistical methods are preferred in that they provide information that non-parametric methods do not. For example, in the two-factor analysis of variance (ANOVA), a test for an interaction may be made. It is more difficult to assess.

In addition, parametric methods usually have great power efficiency when compared to non-parametric methods. Power-efficiency is a technical concept that refers to the probability that the a test will reject the null hypothesis when that hypothesis is in fact false. If the difference between the central tendencies of two groups is being considered, a t-test is more likely to detect a population difference than is an appropriate non-parametric test for the given numbers. Therefore, parametric inferential statistics methods are procedures for statistical hypothesis testing which major assumption is that the

distribution of the variable measured is normally distributed or belong to parametrized families of probability distribution. Parametric statistics require that certain conditions be met in order for them to be valid. The following are important assumptions that are made when using parametric statistics to test hypotheses.

(i) The variable measured is normally distributed in the population.

(ii) The normal distributions have the same standard deviations.

(iii) The data is taken from an interval or ratio scale.

SOME PRINCIPAL PARAMETRIC STATISTICS

1. The T-Test: The test is used to determine whether two means are significantly different when the sample size is small (i.e. n<30). When the sample population is more than 30, the adjusted t-test with the aid of computer could be used. When most of the information is contained in the original data in comparison of two groups, there must always exist a difference no matter how identical the group are. The two types of t-test are the t-test for independent samples and t-test for non independent samples.

Independent samples are samples, which are randomly formed. The members of one group are not related to members of the other than that they are selected from the same population. In a nutshell, the t-test of independent samples is used to determine whether there is probably a significant difference between the means of the independent samples. The formula for t-test for independent samples is:

$$T = \frac{\overline{X_1}(SD_1)^2 + \overline{X_2}(SD2)^2}{\sqrt{(n_1 + n_{2)}}}$$

$\overline{X_1}$ = is the mean of the first group

$\overline{x_2}$ = is the mean of the second group

$(SD_1)^2$ = standard deviation square of the first group

$(SD_2)^2$ = standard deviation square of the second group

n_1 is the number of population in the first group and

n_2 is the number of population in the second group.

2. T-Test For Non-Independent Samples: Non-independent samples are samples formed by some types of matching. When samples are not independent, the members of one group are systematically related to the members of the second group. Therefore, the test for the non-independent samples is used to determine whether there is probably a significant different between the means of two matched or non-independent sample at two different times.

The formula for t- test of non-independent samples is

$$t = \frac{\sum d}{\sqrt{(N\sum d^2 - (\sum d)^2)/N-1}}$$

D = difference between each matched sample

$\sum d$ = sum of difference between the matched samples

d^2 = the square of the difference between the samples

N = total number of matched samples

N-1 = number f degree of freedom.

3. The Z-Test: The z-test is used to determine whether two means are significantly different. It is usually adopted when the sample size is large i.e. when it is equal to or greater than 30.

The formula for calculating z-test is

$$Z = \frac{X_1 - X_2}{\sqrt{Var_1^2/N_1 + Var_2^2/N_2}}$$

Where,

$\overline{X1}$ = mean of group I

$\overline{X2}$ = mean of group II

SD = standard error between means

Var^2 = variance squares of group I&II

4. Analysis of Variance (ANOVA): The analysis of variance (ANOVA) is used to determine whether there is a significant difference between means of three or more groups concurrently at a selected probability level. ANOVA always detects the difference and brings out the cause and causes of such difference.

Analysis of variance is a way of partitioning sum of squares by their source. It allows a wide range of research designs involving one, two or more independent variables to be studied simultaneously.

The analysis of variance as an inferential parametric statistical method is adopted for use if the following conditions prevail:

(i) Random sampling and independent of groups
(ii) Group concerned are more than two
(iii) Homogeneity of group variance
(iv) Normality of population distribution
(v) There exist fixed factors
(vi) The groups of interest are interval or Ratio
(vii) When there is equivalent covariate

There are two main types of ANOVA. One-way ANOVA and Two-way ANOVA. All calculations of analysis of variance end up with the calculation of F-ratio.

4a. One-Way ANOVA: This version of ANOVA applies to the case where there is one independent variable and three or more samples of subjects each sample measured at a different level of variable. The analysis of variance consists of the under listed procedures.

(a) The variance of the scores for three groups are combined into one composite groups known as the total group variance (Vt)

(b) The mean value of the variances of each of the three groups computed separately is known as within-groups variance (Vw)

(c) The difference between the total group variance and the within-group variance is known as the between group variance (vt - vw =Vb)

(d) The F.Ratio is computed as Vb = between group variance
Vw = within group variance
F.ratio is named after Sir Ronald Fisher. The significance of F. ratio is found in the F.table which indicates the critical value necessary to test the null hypotheses at selected levels of significance
$F = \frac{Msb}{Msw}$

4b. Two-Way Analysis of Variance: Two-way analysis of variance is a procedure that examines the effect of two independent variables concurrently. It allows the researcher to look at two things for the price of one and to determine whether the two independent variables interact with respect to the effect of the independent variables.

In considering the effects of the two independent variables separately, what the two-way analysis of variance actually examines is the difference among the means of the column variable. These two sets of the differences are known as the "main effect" of the analysis as distinguished above and beyond the two main effects.

5. Analysis Of Covariance (ANCOVA): Analysis of covariance (ANCOVA) is a statistical test that can be used for research work when one is dealing with more than two groups. The groups in question are not perfectly randomized most of the experimental research works are fited with the use of analysis of covariance. It permits large data for its administration. It is strictly quantitative.

(i) Assumption of its adoption
(ii) Randomization is not perfect
(iii) There is independent selection
(iv) More than two groups must be existing as variables of interest
(v) Normality of group distribution
(vi) Scale of measurement at interval ratio in nature
(vii) The groups concerned not equivalent
(viii) Pre-test serves as covariance.

Summarily, this paper has examined:

- The concept of research as the spring board for all round development,
- Research activities as related to evaluation and development,
- Why the larger society and academia needs research,
- Types of research and their related attributes,
- Research process were listed and briefly explained,
- Research design was defined and its indispensability in research work itemized,
- The concepts of statistics were examined,
- The major division of statistics were listed and chronologically explained,
- Parametric statistics as one of the most powerful methods in research analysis was examined theoretically and conceptually,
- Statistical analysis as a deterministic step in research work was thoroughly highlighted,
- Principal parametric statistics were mentioned, their peculiar characteristics listed and explain, and their formulae itemized,
- Parametric inferential statistical hypotheses are procedures for statistical hypothesis testing. The major assumption is that the normal distribution of the variables measured belongs to a parameterized family of probability distributions,
- The t-test is used to determine whether two means are significantly different at a selected probability level,
- There are two types of t-test for independent samples and the t-test for non-independent samples,
- The analysis of variance is used to determine whether there is significant difference means of three or more groups concurrently at a selected probability level,
- There are two main types of ANOVA- one-way and the two-way ANOVA,
- The one-way ANOVA applies to the case where researchers have one independent variable and three or more samples with each sample measured at a different level of variable,
- Two-way ANOVA is a procedure that examines the effect of two independent variables concurrently,
- Analysis of covariance (ANCOVA) is an inferential parametric statistics dealing with large volume of data. It permits three or more groups. Pre-test in experimental studies serves as covariates.

RECOMMENDATIONS

Based on the explanation of the concepts in this article and based on the findings from the literature, it is hereby recommended that:

1. Governments at all levels and other stakeholders should, as a matter of priority, give research grants to all post-graduate students in the country. This provision will go a long way to promote valid research works and thus enhance credibility of the outcome of those research works.

2. All tertiary institutions (University, Polytechnics, and Colleges of Education and Technology) should encourage their staffers to attend national and international conferences, workshops, and seminars to up-date their knowledge and skills in research works and to make them relevant to the global dynamic change in the world of academy.

3. Trained, experienced, and well-exposed researchers should be allowed to teach courses or handle research works at both undergraduate and graduate levels.

4. With the emergence of information and communication technology (ICT) into research, every post-graduate student should be encouraged to become computer literate during their course of study so as to make their work more relevant in data collection, analysis, and interpretation especially those aspect that has to do with ICT.

5. Manual calculations of various statistical methods should be encouraged among doctoral students. This is an era of advance technology no doubt, but manual dexterity in calculating those statistics will improve the quality of those processed data so as to decode correctly and interpret appropriately all those clumsy data in research work.

CONCLUSION

In view of the relevant nature of research work as a springboard upon which other developments (economics, social, educational, technological, scientific, etc.) revolved, concerted efforts should be made by every stakeholder to promote a genuine culture of research among people so that

the country at large would benefit profusely from the rewards of enquiry knowledge. By extension, our country can take her position among the technologically advanced countries of the world.

REFERENCES

1. Adeniji, I.A. 1990. "A Path Analytic Study of Some Teachers Characteristics and Teacher Job Performance in Secondary Schools in Ogun State".

2. Cronbachi, L.J. 1999. *Essential of Psychological testing, 3rd Edition*. Haper and Row: New York, NY.

3. Minimum, E.W. 1980. *Statistical Reasoning in Psychology and Education*. John Wiley & Sons: New York, NY.

4. Kuder, G.F. and Richardson, M.W. 1939. "The Theory of Estimation of test Reliability". *Psychometrics*. 2:151-160.

5. Levin, J.R. 1985. "Some Methodological and Statistical "Bugs" in Research. *Cognitive Learning and Memory in Children*. Brainerd (ed). Springer-Verlag: New York, NY.

6. McCall, R.B. 1980. *Fundamental Statistics for Psychology*. Harcourt Inc.: London, UK.

7. Ojerinde, Dibu. 1986. *Education Tests and Measurements*. Dodat Audio Visual Service: Ibadan, Nigeria.

8. Olaewe, O.O. 2003. "Concepts of Evaluation and its Models, Case of Semantic Clarification". *College Review*. Osun State College of Education Ila-Orangun Vol. II, pages 304-313.

9. Olaewe, O.O. 2005. "Choosing Appropriate Statistical Methods: A Pathfinder to Research Analysis". *Journal of Contemporary Issues in Education*. University of Ado-Ekiti. 3(1):1-13.

10. Olaewe, O.O. 2006. "Roles of Statistical Methods in Education Research". *International Journal of Research in Education*. 3(2):242-248.

11. Olaewe, O.O. 2006. *Test and Measurement in Education: An Illustrative Approach*. Destiny Publications Nig. Ltd.: Ondo, Nigeria.

12. Olaewe, O.O. 2006. *Education Research Methods "An Analytic Approach*. Fobol Publications Nigeria Ltd.: Ilesa, Nigeria.

13. Olayinka, A.I., Taiwo, V.O., Raji Oyerinde, A and Farai, I.P. 2005. *Methodology of Basic and Applied Research.* University of Ibadan: Ibadan, Nigeria.

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