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The Problems and Prospects of Experimentation

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Authors' contributions

This work was carried out in collaboration among all the authors. Author FAA initiated the concept of the paper, while author KOO prepared the draft of the paper. Author EAI proof read and contributed to the list of references. All authors read and approved the final manuscript.

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ABSTRACT

There are two issues surrounding design and establishment of experiments. Among these is even when resources are available, it may be difficult to conduct purpose driven research. On the other hand, in the midst of scarce resources, there are often unrecognized opportunities. These challenges may be due to ignorance of the components of experiments which should not be ignored or taken for granted. These two limitations of researchers retard the progress and contribution of research to knowledge and development. The objective of this paper therefore was to provide a guide that will stimulate and sustain research interest through experiments that can impact positively on the scientist, work place and the society. In this regard, attention should be paid to the four cardinal aspects of an experiment, which are planning, conduct, data collection, collation and storage, data analysis and writing or documentation of report.

Keywords: Experiment; research; methods; design.

1. INTRODUCTION

An experiment is a test to determine the probable or actual course of event(s). It is called experiment because it has a defined procedure and purpose. The concept of purpose suggests that it will address at least an issue and the procedure means it can be repeated to obtain same results or the procedure can be adapted to address similar issues. Experiments may be

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planned or incidental. For instance, a little baby plays with candle light for the first time and he is hurt. Next time the baby will avoid candle light because the procedure of touching candle light produces painful outcome. Many prehistoric events were detected by accident such as fire by accident of impact of two stones and hence the repeated incidence of fire thereafter by ancient persons. It is also believed that roasting of a product before eating was detected by accident as the plant or animal product that suffered the effect of wild fire was more palatable than the raw item.

Organised study whether in science or the arts, involves planned experiments either consciously or unconsciously. The aspect of unconscious experiments includes such instance whereby a study is conducted after an event has taken place. For instance, Omokhafe and Sagay [1] studied the influence of fire and termite on field survival of budded stumps. The authors did not inflict fire, neither did they plant termite hills on the field. Rather, there was wild fire in a new plantation and the authors took their observations. Dead stumps were uprooted and observed for incidence of termites to evaluate effect of termite infestation on field survival of budded stumps of *Hevea brasiliensis*.

For consciously planned experiment, it starts with a problem that requires solution. This is the reason why virtually every paper will ask for statement of problem before the objective of the paper. The problem to be solved by an experiment may be real or perceived. A problem is perceived at such a time when the immediate community may not recognise the situation as a problem. For instance, at the time of investigation of the force of gravity, man had no issue with gravity, yet it was of concern to Isaac Newton [2]. It was observed that an object will fall downwards instead of any other direction. Unknowingly, the study on gravity prepared the ground for all aspects of engineering. What may have been considered unnecessary then is a universal principle that must be observed in all aspects of engineering. Another example is the concern of climate change in the 19th Century. It generated a lot of controversy and proponents of 'perceived' climate change were ignored but in the following century and more in the 21st Century, climate change has become a well-known occurrence [3,4].

Even in a problem situation that requires investigation, a scientist may not have the courage to conduct an experiment due to scarce resources. Sometimes resources are available, yet carrying out an experiment may be full of uncertainty. In addition, an experiment may be conducted but with poor finishing. These limitations can be overcome with knowledge of the features of a successful experiment. In this regard, the objective of this paper was to provide an overview of the features of an experiment.

2. FEATURES OF AN EXPERIMENT

Design and establishment of an experiment must consider planning, conducting, analyzing and interpretation of results. On a general note, an experiment should consider factor(s) to be investigated and their various levels, blocking, randomisation and replication [5]. Features of an experiment include:

a. Planning such as background information, available resources and field or laboratory design. This conceptual stage is vital to the overall success of the experiment. This is the sole responsibility of the author(s) of the experiment. Summary of components of planning is as follows:

   i. Background information: There must be some preceding information. An experiment must recognize previous work in the same or related area. For instance, new as biotechnology appeared to be a few decades ago, totipotency of plants was already well documented.
   ii. The available resources: This may be *in situ* or outsourced. Working environment can be managed by utilizing *in situ* or outsourced resources, rather than abandon the investigation. For instance, biotech research in a developing country may not be as sophisticated as same research in the high tech research laboratory in a developed country.
   iii. Design: Every experiment should have a design. In this case, an investigation cannot be arbitrary. The design will affect the quality of the result. A design, while taking cognizance of available resources, should recognize the various sections of the problem under investigation. This will ensure that the problem is addressed holistically. For instance, study on influence some social factors affecting rubber cultivation in Nigeria considered age as a factor and

the age of farmers was categorized into several groups [6]. Every factor to be considered in an experiment should be in various categories such as various clones in breeding trials, concentration levels of chemicals, levels of temperature applied to dry seeds, etc.

Common experimental designs include completely randomized, completely randomized block, nested, split plot, lattice in apparent increasing order of complexity [7]. It is often assumed that the higher the complexity, the more sensitive the experiment, and hence better. In plant breeding, there are mating designs such as full sib, half sib, diallel, north carolina etc [8]. Mating designs assist plant breeders to obtain genetic information from experiments, yet mating designs may be applied on non-breeding trials as was the case of rootstock-scion compatibility study by Sagay and Omokhafe [9] using diallel design.

iv. Replication: In agricultural research, there must be replication. A replicate is a repetition of a treatment. This repetition is necessary to capture the environmental variation that exists in nature. A plot of land irrespective of the size cannot be uniform neither will a ranch or pen for animals have same conditions from East to West or North to South. Even in controlled experiments, the circulation of air or temperature cannot be the same all through the chamber and at the same time.

v. Control: This is a factor that is already tested or well known to the practitioners. For instance, RRIM 600 and/or GT 1 may be used as control clone to test new clones of *Hevea brasiliensis*. Ethephon may be used as control to evaluate new latex stimulants for exploitation of *H. brasiliensis*.

b. Conducting the experiment: This includes setting up of the experiment, data collection, data collation and storage. This is an area where the authors can and in many cases must involve supporting staff such as agricultural superintendents, laboratory technologists/technicians and field assistants. It involves:

i. Setting up the experiment: As soon as the resources are assembled and a suitable design is developed, the establishment of the experiment follows. It involves translation of the design on ground in field experiments or in test tubes, beakers, flasks, cylinders, etc in the case of laboratory experiments. In conducting the trials, there should be no discrimination against any factor. There should be neither bias nor sentiment. This is called randomization. In the case of field trials, gradient may be considered such as topography or fertility gradient. Labeling is very important to avoid mix up of the treatments. Labels should be weather tolerant all through the experiment.

ii. Data collection: This is record of observations at regular intervals. For instance, monthly yield data collection in *Hevea brasiliensis* should be carried out except for the period of annual break in February/March. Frequency of record keeping depends on the character under consideration. Data recording should be in field notebooks preferably with pencil to avoid blotting of ink.

iii. Data collation/storage: The raw data from the field may be transferred to a more permanent record book in custody of the scientist, while raw data notebook may be returned to the field staff. Storage of data may be in hard and soft copies. The soft copy may be shared among participating scientists to avoid total loss in case of ‘one man custody’.

c. Data analysis involves treatment of the data to produce trends than can be interpreted. It is noteworthy that data analysis will be easier to handle if there was adequate experimental design. Data analysis can be carried out by the authors or with the assistance of data management technicians. This is where data software such as GENSTAT, SPSS, SAS etc may be used. It may involve simple calculations such as mean, mean separation, range and percentage. Correlation and regression analysis, analysis of variance and covariance may be necessary.

Some specialized analysis may be applied. For instance, path analysis is used to detect direct and indirect effects of characters based on phenotypic or genotypic correlation [10]. Path analysis can be applied in studies on nutrient or

social factors. Stability analysis is conducted to explain the trend of variation across various environments of time, space, location, treatments etc [11].

d. Writing of project reports, periodicals and papers. This marks a good end to experimentation. It is the main responsibility of authors in order to know what to report, how to report and what to leave in the files. It will also provide new investigations that are necessary off shoot of the study. The language should be simple, direct and self- explanatory. There should no assumptions or presumptions, rather authors should dwell on the results of the experiment. The report should conform to the format of the journal, bulletin, proceedings, etc.

3. CONCLUSION

Experimentation is as old as man, as present day civilization is a product of continuous experiments for improvement in the quality of life of mankind. Experiment, therefore is to solve problems and no experiment is too small to make meaning. The meaning derivable from an experiment depends on the skill and attention given to it by the investigator. Such meaning may be elusive without adequate knowledge of the stages of experimentation. Sometimes, these stages may be known but ignored. Paying attention to the features of an experiment can therefore improve the skill of researchers. The recommended stages are planning, experimentation, data management and report writing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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