EXPERIMENTAL DESIGN (A Brief Review)

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A designed experiment is a test or series of tests in which purposeful changes are made to the input variables of a process or a system so that we may observe and identify the reasons for changes in the output response.

The objectives of the experiment may include the following:

(i) Determining which variables are most influential on the response.
(ii) Determining where to set the influential variables so that the response is almost always near the desired nominal value.
(iii) Determining where to set the influential variables so that variability in the response is small.
(iv) Determining where to set the influential variables so that the effects of the uncontrollable variables are minimized.

The experimental material is comprised of **experimental units** on which a treatment which is to be tested is applied. An experimental condition whose effect is to be measured and compared is called treatment and it is applied onto the experimental unit randomly.

There are three basic principles of experimental design i.e., replication, randomization and local control.

The repeated application of treatment under investigation is called replication.

1. ***Replication*** -- By replication we mean a repetition of the basic experiment. In other words it is a complete run for all the treatments to be tested in the experiment. In all experiments some variation is introduced because of the fact that the experimental units such as individuals or plots of land in agricultural experiments cannot be physically identical. This type of variation can be removed by using a number of experimental units. We therefore perform the experiment more than once i.e., we repeat the experiment. An individual repetition is called a replicate. The number, the shape and the size of the replicate depend upon the nature of the experimental material. A replication is used:
   - (i) To secure an estimate of the experimental error (a term which represents the differences that would be observed if the same treatments were applied several times to the same experimental units).
   - (ii) To decrease the experimental error and thereby to increase precision (which is a measure of the variability of the experimental error).
   - (iii) To obtain more precise estimate of the mean effect of a treatment, since $\sigma_{\bar{Y}}^2 = \frac{\sigma^2}{n}$, where n denotes the number of replication.
2. ***Randomization*** -- Randomization is the corner stone underlying the use of statistical methods in experimental design. By randomization we mean that both the allocation of the experimental material and the order in which the individual runs or trials of the experiment are to be performed are randomly determined. Statistical methods require that the observations (or errors) be independently distributed random variables. Randomization usually makes this assumption valid. By properly randomizing the experimental treatments, we also assist in "averaging out" the effects of extraneous factors that may be present and eliminate the element of any bias in favour of any particular treatment.
3. ***Local Control*** – It has been observed that all extraneous sources of variation are not removed by replication and randomization. This necessitates a refinement in the experimental technique. In other words, we need to choose a design in such a manner that all extraneous source of variation are brought under control. For this purpose, we make use of local control, a term referring to the amount of balancing, blocking and grouping of the experimental units. Balancing means that the treatments should be assigned to the experimental units in such a way that result is a balanced arrangement of the treatments. Blocking mean that similar experimental units should be collected together to form a relatively homogeneous group. A block is same as a replicate if it contains a complete set of treatments. The main purpose of the principle of local control is to increase the efficiency of an experimental design by decreasing the experimental error.

The word control in experimental design is also used for a treatment, which does not receive any treatment but we need to find out the effectiveness of other treatments through comparison with the control. Therefore it should not be confused with the term local control which means balancing, grouping.

The term experimental error or error variance is a measure of variation among experimental units treated alike and it works as a yardstick to measure the significance of differences using statistical tests.

Types of Experimental Designs:

1. ***Completely Randomized Design:*** Completely Randomized Design is a design in which the treatments are assigned to the experimental units completely at random, that is the randomization is done without any restriction. The design is completely flexible i.e., any number of treatments and of