Design and Analysis of Experiments

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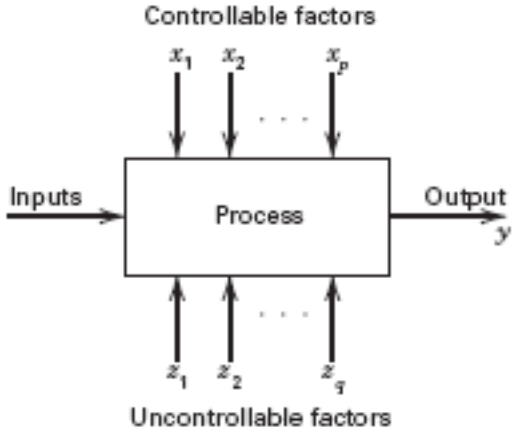
Introduction to DOX

- An **experiment** is a test or a series of tests
- Experiments are used widely in the engineering world
  - Process characterization & optimization
  - Evaluation of material properties
  - Product design & development
  - Component & system tolerance determination
- "All experiments are designed experiments, some are poorly designed, some are well-designed"

Engineering Experiments

The **objectives of the experiment** may include the following:

- Determining which variables are most influential on the response y
- Determining where to set the influential x's so that y is almost always near the desired nominal value
- Determining where to set the influential x's so that variability in y is small.
- Determining where to set the influential x's so that the effects of the uncontrollable variables $z_1, z_2, \ldots, z_q$ are minimized.



■ FIGURE 1.1 General model of a process or system

The Basic Principles of DOX

- **Randomization**
  - Running the trials in an experiment in random order
  - Notion of balancing out effects of "lurking" variables
- **Replication**
  - Sample size (improving precision of effect estimation, estimation of error or background noise)
  - Replication versus repeat measurements? (see pages 12, 13)
- **Blocking**
  - **involves** making **comparisons among the conditions** of interest in the experiment **within each block**.

Planning, Conducting & Analyzing an Experiment

1. **Recognition of & statement of problem**

   It is necessary to develop all ideas about the objectives of the experiment.

   A clear statement of the problem often contributes substantially to a better understanding of the phenomena and the final solution of the problem.

2. Choice of factors, levels, and ranges

The experimenter must choose the factors to be varied in the experiment, the ranges over which these factors will be varied, and the specific levels at which runs will be made.

3. **Selection of the response variable(s)**

In selecting the response variable, the experimenter should be certain that this variable really provides useful information about the process under study. Most often, the average or standard deviation (or both) of the measured characteristic will be the response variable.

Multiple responses are not unusual.

4. **Choice of design**: involves**:**

The consideration of sample size (number of replicates),

The selection of a suitable run order for the experimental trials,

And the determination of whether or not blocking or other randomization restrictions are involved.

In selecting the design, it is important to keep the experimental objectives in mind.

5. **Conducting the experiment**

it is vital to monitor the process carefully to ensure that everything is being done according to plan.

Errors in experimental procedure at this stage will usually destroy experimental validity.

Up-front planning is crucial to success.

6. **Statistical analysis**

Statistical methods should be used to analyze the data so that results and conclusions are objective rather than judgmental in nature.

Residual analysis and model adequacy checking are also important analysis techniques.

There are many excellent software packages designed to assist in data analysis.

7. Drawing conclusions, recommendations

Once the data have been analyzed, the experimenter must draw practical conclusions about the results and recommend a course of action.

Follow-up runs and confirmation testing should also be performed to validate the conclusions from the experiment.

Throughout this entire process, it is important to keep in mind that experimentation is an important part of the learning process, where;

1- We tentatively formulate hypotheses about a system,

2- Perform experiments to investigate these hypotheses, and

3- On the basis of the results formulate new hypotheses, and so on.

- **This suggests that <u>experimentation is iterative</u>.**