The Art of Experimentation

A set of well designed experiments and careful observations, together with the theory, can lead to a prediction of performance. The working model can be designed based on these results.

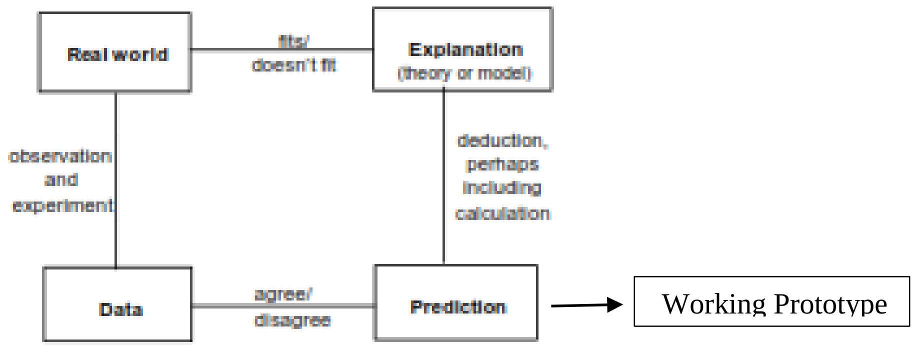


Figure 1 **A model of scientific reasoning (based on Giere, 1991)**

Simulations and models can be used to generate data much faster and more economically than constructing a series of protypes. However, some models, such as the rocket simultor may have many input variables. It may not be feasible to change one variable at a time. Also, the input variables may be interacting, that is, the effect of one input variable on the output may depend on the value of another input variable. Obviously, this leads to a set of results that is difficult to interpret correctly.

Experimental Design

The strategy and design of an experimental program is a major topic in its own right. It is important to have some awareness of the difficulties so that you can perform your simulations efficiently. The Introduction to Experimental Design: Fundamental Concepts (3 ed 2001, William Diamond), in the Reading Section presents an overview.

Read the sections:

Origins of Bad Experiments*
Philosophy of Good Experiments
Project Strategy*
Experiment Strategy*

For each of the sections marked, *, identify an important point and add several sentences to its relevance to the rocket simulation.

Note: There are some references which are not relevant to this project (for example statistics and statisticians, these can be ignored.) The important point is to see what is recognize the information that can make your simulation work more effective.

Strategy of Experiments:
Practices from the Responses to Introduction to Experimental Design: Fundamental Concepts (Diamond)

Incorporate these points into the strategy for the **Water Rocket Design Simulation**

State the objective of the work clearly and succinctly

Identify a strong starting point

Do not rely on the one-factor-at a time approach

Specify **all** variables that would influence the end results

Variables can sometimes be evaluated in groups or relative importance

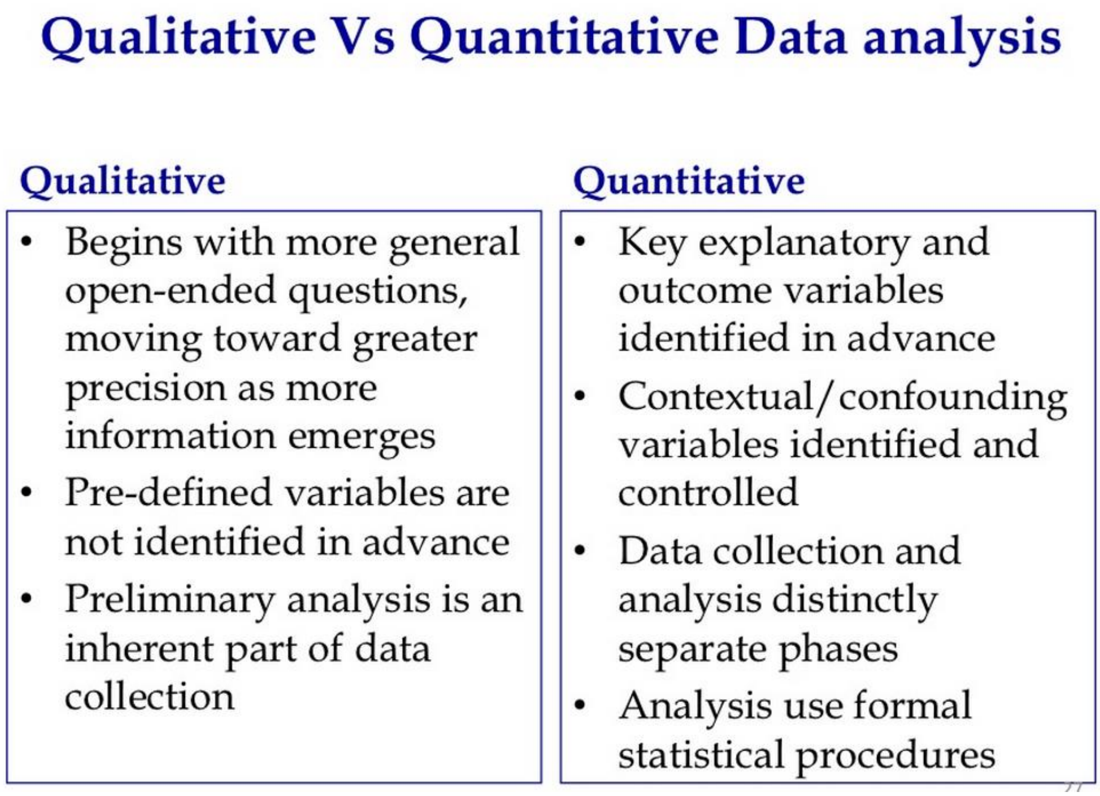
Interactions between variables must be checked

The basic scientific principles must be understood for simulation results to be interpreted

Develop your own questions to be answered by the experiments

Early trials can lead to insight, which can be applied to later trials.

Do a reality check between the experiments and the final physical system. Does the exercise make sense?



http://www.slideshare.net/tilahunigatu/qualitative-data-analysis-11895136

Quantitative Experimental Data Analysis

Principles

- Look at ALL the data   (not just the final result).
  (Are the data complete and accurate)

- Review your observations, equipment and procedure for systematic errors

- Apply the theory (Quantitative calculations)

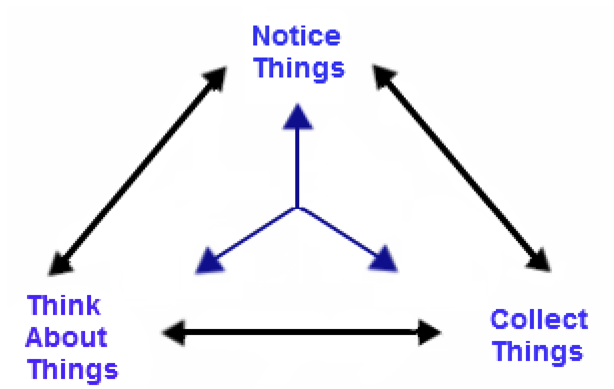
- Compare the data in different ways to get insight into relationships
  (Tables, figures, flowcharts, diagrams, narratives)

- Analyze Relationships
  (Outliers, accidental relationships)

- Make a recommendation for a change and consider the consequences.

Qualitative Data Analysis: Notice/Collect Think Model

“Analysis is a breaking up, separating, or disassembling of research materials into pieces, parts, elements, or units. With facts broken down into manageable pieces, the researcher sorts and sifts them, searching for types, classes, sequences, processes, patterns or wholes. The aim of this process is to assemble or reconstruct the data in a meaningful or comprehensible fashion” (Jorgensen, 1989: 107).



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NCT J Seidel 1998 http://www.scribd.com/doc/7129360/Seidel-1998-Qualitative-Data-Analysis

Seidel (1998) developed a useful model to explain the basic process of qualitative data analysis. The model consists of 3 parts: Noticing, Collecting, and Thinking about interesting things. These parts are interlinked and cyclical. For example while thinking about things you notice further things and collect them.

The process has the following characteristics

Iterative and Progressive
The process is iterative and progressive because it is a cycle that keeps repeating. For example, when you are Thinking about things you also start noticing new things in the data. You then collect and think about these new things. In principle the process is an infinite spiral.

Non-Linear
The process is recursive because one part can call you back to a previous part. For example, while you are busy collecting things you might simultaneously start noticing new things to collect

.

Interrelated
The process is holographic in that each step in the process contains the entire process. For example, when you first notice things you are already mentally collecting and thinking about those things

The Process of Qualitative data analysis

Step 1: Organize the data

Step 2: Identify framework

Step 3: Sort data in to framework

Step 4: Use the framework for descriptive analysis

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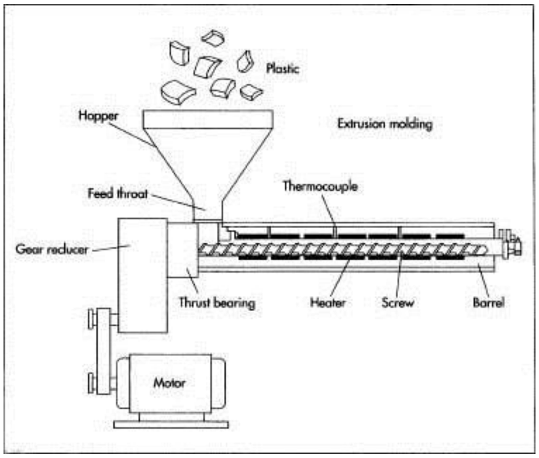
Problem: Strategy of Experimentation

1. It is your first day on the job as a production engineer. You are asked to get an extruder to operate efficiently. The goal is to operate at the highest rate and make acceptable product. You don't know what an extruder is, but you do know something about experimental strategy and risk assessment.

Your new boss tells you that plastics extrusion is a high volume manufacturing process in which raw plastic material is melted and formed into a continuous profile. Extrusion produces items such as pipe/tubing, fences, and window frames. He shows you the diagram below.

Pellets of plastic are loaded in the hopper and fall into the barrel. The barrel is heated (temperature measured by a thermocouple) and the melted plastic pumped through the barrel. At the end of the barrel, the plastic comes out through a small hole and is formed into useful parts. **The only variables that can be changed are the temperature of the plastic and the flow rate.**



Information Available (2 variables)

Melting temperature of plastic 250° C
Decomposition Temperature of plastic 300°C

Maximum flow rate at which plastic can be transported through the barrel 5 kg/minute

First Experiment (by previous engineer)

Conditions: 260° C Flow Rate: 2 kg/min. Product Quality: Acceptable

Extruder experiments are very expensive and time consuming. Your boss gives you 1 trial and then, based on the results of that trial, requires you to make a recommendation for the production operation.

a) State the goal of the experiment in terms of temperature, production rate and set a strategy to meet this goal.

b) Identify and state experimental conditions (temperature and flow rate) that will give you the most useful information from one experiment. State the reasoning for your choice of conditions. Identify risk assessment factors that may have been a consideration in your choice.

c) If your test does not produce acceptable product, what is your recommendation, with reasoning, for the production conditions