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# WEBBASED SIMULATION- ENVIRONMENTS FOR VIRTUAL EXPERIMENTATION

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# Outline

1. Learning to design and analyze experiments
2. Virtual experiments on the web
3. The EN2EXP library:
  - Sampling bottles on a conveyor belt
  - An industrial experiment
  - A greenhouse experiment
  - Diesel contamination around a railroad track
4. A simple alternative approach
5. Interactive learning of statistical concepts

# Learning experimental design

## A typical example from a DOE textbook

A Box-Behnken design was used to determine whether specific drying conditions for a process could yield a resin with more high-molecular-weight components. The three factors under study were temperature (150, 185, 220°C), relative humidity (0,50,100%), and air pressure (1,5,9 torr). The response was a measure of product degradation (ppm). The design and data are in table...

Fit the second order model, test for lack of fit, conduct a canonical analysis.

# Some criticism!

- Design questions
  - Why these factors?
  - Why these levels?
  - Other factors ignored?
  - Randomization?
  - Why Box-Behnken?
- This exercise is all analysis – no design!
- No problem solving step involved
- This type of exercise does not prepare a student for the realities of designing experiments

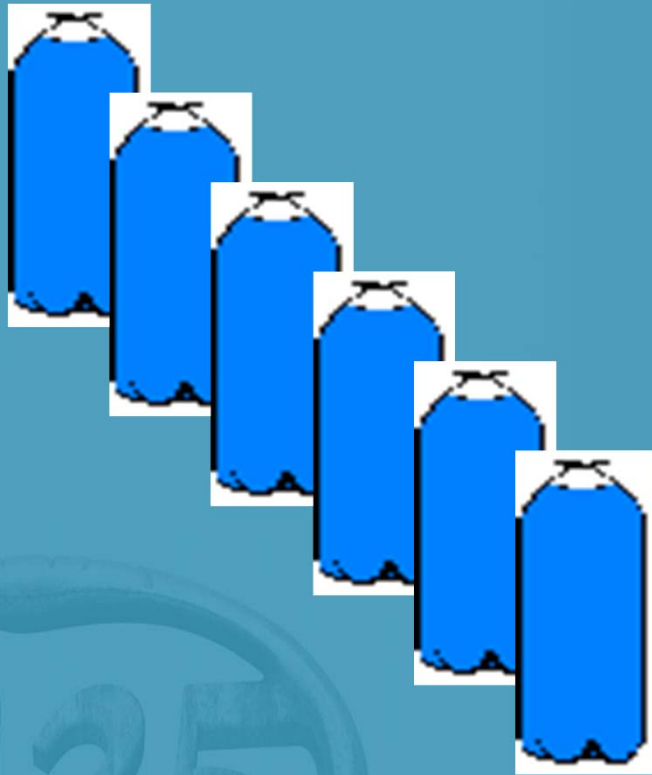
# Alternative approaches

- Ask students to perform an experiment of their choice
  - Very labour- and resource-intensive
- Ask students to perform a « prepared » experiment in the lab
  - Very labour- and resource-consuming
- Ask students to experiment with a pilot plant
  - Very labour- and resource-consuming
- Ask students to experiment within a software-based environment that mimics a situation of interest
  - Allows repeated experience
  - Feasible for large classes
  - Distance learning courses
  - Automatic evaluation is possible

# The ENV2EXP environment

- A collection of JAVA applets
- Each applet
  - Mimics a real situation of interest
  - Allows data collection, but in many ways
  - Produces noisy responses, based on a realistic (hidden) underlying model
- Freely accessible over the web
  - <http://lstat.kuleuven.be/env2exp/index.html>
- The produced datasets are transferred to statistical and/or simulation soft
- The user can relate the quality and characteristics of the analysis results to the data collection strategy
- Emphasis lays on data acquisition

# Conveyer belt sampling of softdrinks



Study sample  
plans for softdrink  
bottles passing on  
a conveyer belt



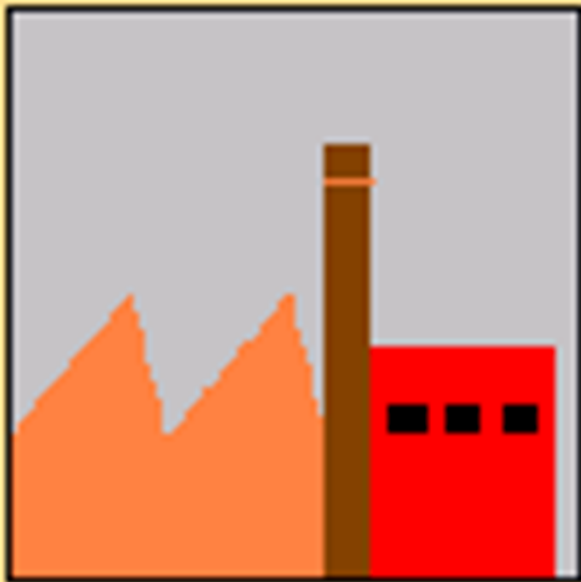
# Random sampling

Underlying model:  $\text{pH} = f(\text{CO}_2, \text{Temp}) + \text{error}$

## Learning experiences

- Hidden disturbing factors: temperature, partial pressure of  $\text{CO}_2$  in the storage tanks
- Consequences on variability
- Randomisation schemes
- Effects of random sampling
- Necessity of random sampling

# An industrial experiment



**Factory**

Optimising a response in relation to temperature, reaction time and concentration.

Experiment with a pilot plant to optimise the process.

Transfert new operational settings to the factory to maximise returns.

# An industrial experiment

## Learning experiences

- Choice of factors : obvious, but tank=block ?
- Choice of levels: consequences
- Relation pilot plant results - factory results
- Confidence in a result: when to change factory settings
- Sequential experimentation vs one-shot (or anything in between)
- Cost of an experiment: power vs precision
- Need for randomization (hidden time trend)
- Time pressure

# A greenhouse experiment



Mimics a real experimental situation in a greenhouse

Investigating the effect of N-fertilizer dose on biomass production of tomato in relation to disturbing factors: initial plant weight, light and temperature gradients

# A greenhouse experiment

## Learning experiences

- Allows virtually all classical block and row-column designs to be tried out
- Allows the student to try out ad-hoc designs. Fi circular gradients
- Importance of randomization
- Initial weight: block, covariate or ignore ?
- How to block for « irregular, disturbing » factors (light, temperature) ?
- Understand restrictions on randomisation

# Another sampling problem



**Contamination**

Diesel spills around a railroad track.

Investigate the spread of the contamination around the tracks.

K.U. Leuven, Eddie Schrevens, Ken Portier, Paul Darius

# Diesel contamination around a train track

## Learning experiences

- Effects of variability
- Random sampling requires careful planning
- Random vs systematic sampling
- Sometimes random sampling is best, sometimes sampling must be adapted to context
- The context can be changed: other background and underlying model

# Conclusions

Current computer technology allows the creation of special purpose, accessible and rich environments that can, in the field of experimental design, give a learning experience well beyond that of traditional textbook exercises.

But: environments must be carefully selected:

- Situations that appeal to the student
- Balance simplicity-complexity
- Realistic underlying model



# A simple alternative approach

- Data and model, fit a mixed model for heritability studies
- GUI, fit in matlab
- Generating data for different experimental designs



GenEx

# Interactive learning of statistical concepts

The VESTAC set of JAVA applets. Paul Darius.

## Visualization of and Experimentation with STAtistical Concepts

These applets are designed for the purpose of computer-aided education in statistic courses. The intent of these applets is to help students learn some abstract statistics concepts in an interactive way. The approach taken here is based upon visualization and simulation.

# VESTAC index page

Available at

<http://lstat.kuleuven.be/java/index.htm>



Thank you for your attention

