KATHOLIEKE UNIVERSITEIT
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WEBBASED SIMULATION-ENVIRONMENTS FOR VIRTUAL EXPERIMENTATION

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NSS workshop
Statistical research planning Lima, Jimma, Peru, Ethiopia

November 2011, March 2013

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Ethiopia March 2013

Outline

1. Learning to design and analyze experiments
2. Virtual experiments on the web
3. The EN2EXP library:
   - Sampling bottles on a conveyor belt
   - A greenhouse experiment
   - An industrial experiment
4. 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 excercise 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

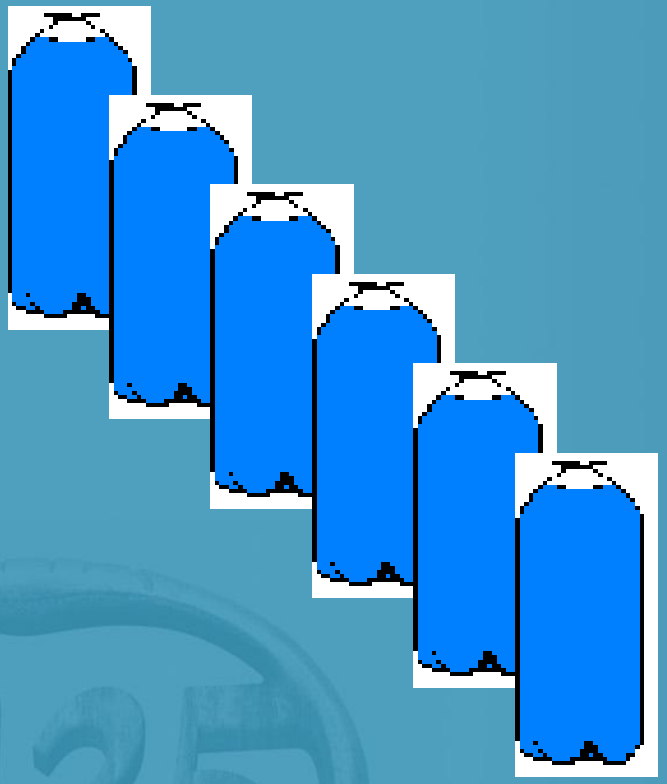
Alternative approaches

- 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

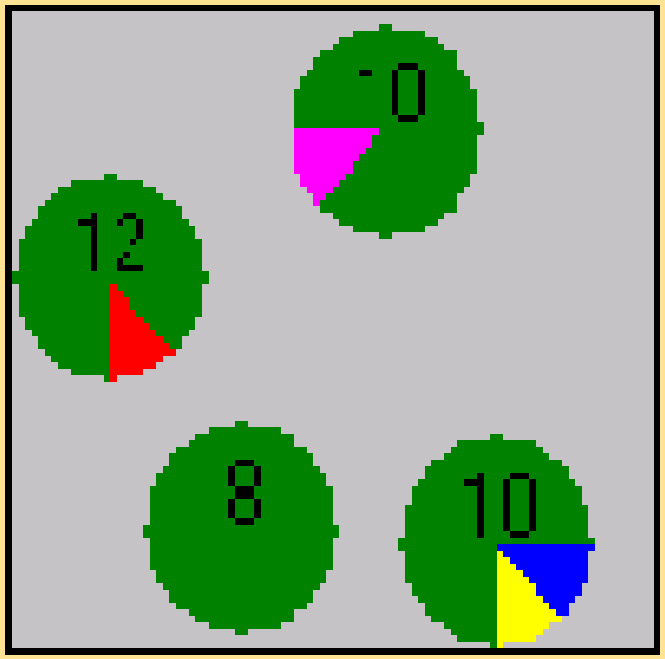
Underlying model: pH = f(CO_2,Temp) + error

Learning experiences

- Hidden disturbing factors: temperature, partial pressure of CO_2 in the storage tanks
- Consequences on variability
- Randomisation schemes
- Effects of randon sampling
- Necessity of random sampling

- Consult a statistician before you start
- Interact with the application field
  - Communicate with the production engineer

A greenhouse experiment



Mimics a real experimental situation in a greenhouse

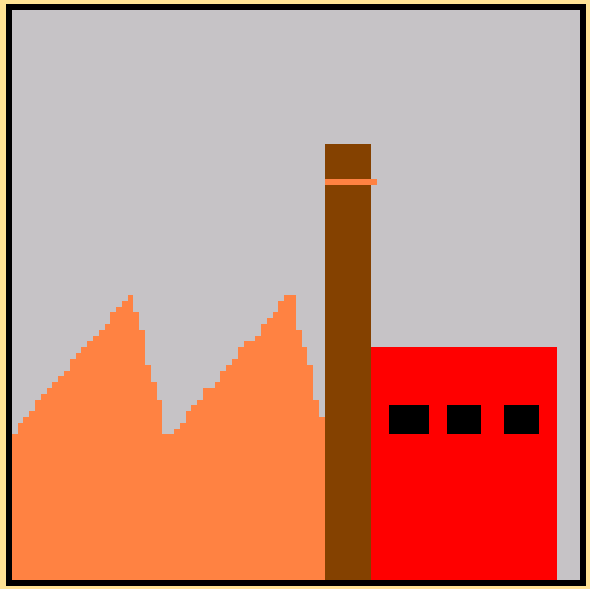
Investigating the effect of N-fertilizer dose on biomass production of tomato in relation to disturbing factors: initial plant weight, light and temperature gradients

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

An industrial experiment



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.

Unilever Research, K.U. Leuven, Paul Darius

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

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

Students critics

Student inquiries

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