Course project

This DOE (design of experiments) mini-project gives you an opportunity to learn about designed experiments in a more hands-on manner.

The project is *not long*, and should *not be elaborate*. You only have a few weeks to plan your experiments, perform them and then analyze the data. Some more examples are given below, but it could be something like optimizing a favourite recipe or dessert, a hobby or sport, or it could be related to work from another course project or your graduate research, which is ideal for 600-level students, or 400-level students doing research projects.

The intention is that you discover for yourself how important the following topics are in DOE. Once you have decided on a system to investigate you will be faced with:

> - Which variables should we use?
> - What range should these variables cover?
> - How do we measure these variables (especially the response variable)?
> - What other variability is in the system, is it measurable, is it controllable?
> - Choosing the type of experimental design, center points, fractional designs, confounding pattern, and handling constraints.
> - How many experiments should be run, are replicates possible, and how to randomize the runs.
> - Understand what George Box means when he says: "*the best time to run an experiment is after the experiment*".

These are issues that are not easily reproduced or understood from assignment questions and quizzes.

Project topics

You might be passionate about your hobby, for cooking, or your research area, *etc*, so coming up with a system to investigate shouldn't be a problem. However, some systems are too complex for the short time you have available, and you might have to cut back to something simpler. So below are some ideas that you can think about and modify, but please work on anything you are interested in, or anything you have ever wondered about. Don't pick a project below that "looks easy": the easy ones are deceptive.

- Yield of stovetop popcorn or microwave popcorn
- Potatoes in a bucket
- Rise height of bread
- Algae growth in an aquarium
- Fuel efficiency (gas mileage) of a car
- The perfect meringue from egg-whites
- Time taken to go down a ski slope
- Factors related to seed germination and growth
- Home-made yoghurt
- Taste of preparing prepackaged foods
- Strength of wood glue bond
- Stain removal from clothes
- Hover time of a paper helicopter
- Flight time or distance of a paper plane or model plane
- Shot distance of tabletop hockey puck
- Bounce height of tennis balls or golf balls

You might be fortunate that you have access to a lab for another course, or that one of your other courses overlaps in some way. You may even have an industrial partner from your co-op or current research area (grad students) with whom you can work. For example, a blown-film line, an extruder, a configurable heat-exchanger, investigating polymers. Try to work with these as much as possible.

Note that topics involving cooking and baking can be the most complex due to raw material variability and subjectivity of the outcome variable(s). However, if this is an area that you/your group is interested in, please try the following:

- Replace subjective measurements of taste with something more measurable, e.g. height of muffin, diameter of cookie, pH, or similar.
- Use recipes that are based on weight; recipes and cookbooks that are based on volume for dry ingredients (cups and teaspoons) are inherently flawed and will introduce disturbances (error). Use recipes that are in terms of mass.
- Some y-variables such as "doneness" or "time to cook" or "firmness" are extremely subjective and hard to measure; there are ways around it in professional laboratories, but you won't have access to this sort of equipment.
- Professional taste-testers are trained for months; rather than just a taste number between 0 and 10, break it down into components: acidity, sweetness, mouth feel (texture), crispiness, "etc", and add up the values to get a composite taste score.
- Rather than just using taste as your response, also analyze the standard deviation of your taster's scores, to find the most robust, and pleasing recipe combination.

Finally, the system under investigation can be anything, however, you cannot merely copy-paste a problem that you found in a book, technical journal, website, or some other resource. You must be able to prove you planned and performed the experiments yourself; this means that you cannot reuse experimental data from a previous course project. If you are going to investigate a relatively simple system, such as dissolving salt in water, then ensure that your project is at the level of a 4th year university project, is comprehensive, and covers many factors. In general the number of experiments, the cost and the complexity of the experiments should be inversely proportional to the duration of each experiment.

If you have any ethical doubts (e.g. experiments on animals or people, or experiments with drugs and controlled substances) then rather choose another system.

Group work

Ensure that the system is of interest to all group members, and that you can all contribute to the work. You may perform this project by yourself, with one other person, or with two other people (400-level students only). 600-level students may also work with one other person in the class (groups of two or less). It makes sense to use the same group members that you worked with in the assignments.

What to hand in

Submit your report as an electronic file (only a PDF will be accepted). The report will be at most 8 pages, of which 5 contain content and 2 are appendices/code. The first page, the cover page, will be your name(s) and student number(s). Your name(s) and student number(s) may not appear on any other part of the document, as it will be graded anonymously by 3 of your peers.

Reports are submitted at the following location: http://yint.org/selfeval - you will first do a peer evaluation of your own report to experience the process. This also gives you a chance to improve your report, because you have the full grading schedule.

- 8% Your own self evaluation; marks will be deducted if you grade yourself dishonestly
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- 60% The average of the grade from the 3 (or more) peers
- 20% My grade of your project
- 4 x 3 = 12% The quality of your grading (based on the quality of your comments) of the 3 peer reports you submit
- 3% bonus for every extra peer evaluations (3 minimum are required). So if you do 5 peer evaluations, you

get (5-3) x 3 = 6%

The following guidelines will help you produce a great report:

- The report must tell a story that describes the problem you want to solve, outlines the factors experimented on, how you identified and controlled for disturbances and provides conclusions.
- Tell a story, please don't use language such as "it shall be shown that ...". Use everyday writing, as if you were describing this to your manager, who understands the statistical tools you are using.
- You may choose to use some or all of these sections in the report:
    1. Describe your objective for the system under investigation. What is/are the outcome variable/s you are investigating; how are they measured?
    2. Outline the factors that you expect will influence the outcome variable. How will you measure the factors, over what range will you vary them? State how you expect each factor to affect the response(s); do you expect any interactions?
    3. Disturbances: which factors are known to affect the response but are not being investigated here? How do you control for them?
    4. Plan an experimental program that will change the system's factors and control for disturbances. Be specific on how you chose your design.
    5. Execute the experimental program, logging all relevant details (e.g. experiments that are "weird", unusual events). Take photos/keep a log sheet.
    6. Analyze the experimental results using the tools introduced in the course.
    7. The conclusions, related back to your original objectives. What would be the next set of experiments you run?
- Optionally place all source code in the appendix. I will generally assume you know how to analyze the data, so I don't have to see code. However, the code may be helpful, if your description in the report is unclear, or if I have doubts when grading the report.
- Appendices and extra information can be attached. You must attach the original/scanned run sheet, and any photos from your experiments.

Guidance

- Feel free to email me with any questions.
- If you are uncertain if your system is suitable, run your idea by me before you go too far.
- Due to the short timeline for this project you should consider systems where experiments take no longer than a day or two each, unless you can run all your experiments in parallel (e.g. growing plants).

Example of a previous project

A good example of the style and type of report required is in Box, Hunter and Hunter, page 215 to 219 (second edition), pages 368 to 272 (first edition).

Time line

11 March 2015 or earlier

You may *optionally* email me a short message, and using bullet points.

- Describe your system, tell me why you interested in the system.
- What is your objective: describe it clearly; describe how you are going to measure it.
- What are all possible variables that can influence your objective?
- Which variables are you going to vary? Tell me the low and high levels you are going to use for each variable.
- Which variables are you going to keep fixed in your experiments?

I will provide general comments in person or by email. The earlier you do this, the longer you have to perform (and perhaps repeat) any of your experiments. Many students in the previous class found this interactive help the most useful part of the course, because there are quite a few pitfalls in designing and analyzing experiments.

05 April 2015

Hand-in of the final project report by 23:00

06 April 2015 Peer grading begins on your own report, and 3 other colleagues reports.