Experiment Design for Computer Sciences (01CH740)

Topic 00 - Course Introduction

Claus Aranha
caranha@cs.tsukuba.ac.jp

University of Tsukuba, Department of Computer Sciences

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What is this course about?

From the syllabus

The collection and analysis of data through experiments is one of the cornerstones of the scientific method. In this course, we study the general philosophy and methods behind experimentalism: Why do we perform experiments, what is a good/rigorous experiment, how to plan and design a rigorous experiment, and how to perform statistical analysis on experimental data.

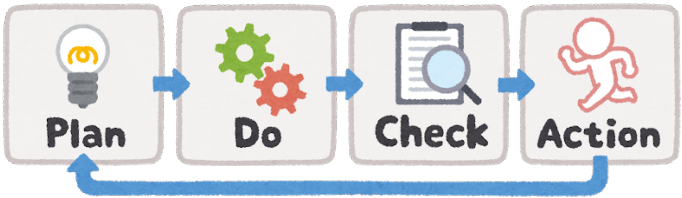
... **TL;DR?**

What is this course about?

TL;DR; (Too Long, Didn't Read)

The key idea of this course is to learn how to plan, execute, analyse and interpret a scientific experiment.

Another way to think is: "Experiment Design" is how to apply the PDCA cycle for science.



What is this course about?

Why is a course on "Experiment Design" necessary?

There are some common errors that I see from students many times:

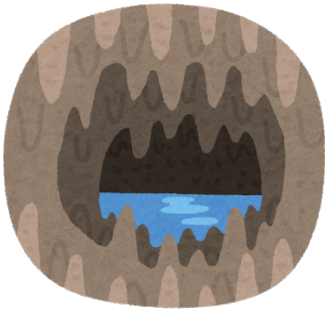
- The experiment does control for noise factors;
  Is the result just a coincidence?
- The experiment that compare two methods is not fair;
  Is the new method really better than the old one?
- The experiment is not reproducible;
  How can this experiment help other people?
- The conditions and assumptions of the experiment are not clear;
  The results and conclusions are questionable
- etc...

What is this course about?

The "Dark Curriculum"

The Dark Curriculum are things that are necessary for your work as an academic, but that you usually can't learn in a lecture, and must discover by trial and error. For example:

- How do I prepare an experiment?
- When do I publish a result?
- How do I review a paper?
- How do I teach a lecture?
- What are grants?
- ...



The goal of this course is to shed light in one of these points: *What is an experiment, and how do I prepare it?*.

Course Topics

The main things that you will learn in this course are:

- What is an experiment:
  - What is the role of an experiment in Science?
  - How do I design an experiment to answer a scientific question?
  - What are the characteristics of a good experiment?
  - How do I analyse the results of an experiment?

- Statistical tools for analyzing experimental data:
  - Basic statistics for data analysis and visualization;
  - Statistical Inference ("Statistically Significant Results");
  - Statistical testing for single, paired, and multiple sample testing;
  - How to calculate the sample size and power of an experiment;

Course Topics

Limitations: This is only an introductory course!

This course is an introduction to design of experiment. My main objective is to teach you **why** designing experiments is important, and what problems can happen when you don't do this. Not to teach all the statistical tests.

Each experiment, in each research, will require a different way of doing statistical analysis. Also, some advanced topics (bayesian statistical analysis) will not be covered here. I hope that after this course you will have a solid understanding of the concepts to read and learn the advanced tests required of your own research.

Practical Details about the course

- Teaching Format;
- Course Materials;
- Course Schedule;
- Grading;
- Course Policy;

Note: these details have small differences from the syllabus. The latest information is always on manaba.

Course Format (Fri, 15:15 to 18:00)

Online (On demand) Format

Video lectures and lecture notes published on manaba by the official lecture time. Please read the video lecture in full, at the time of your preference.

During the official lecture time, I will hold "office hours" on TEAMS. A link will be on manaba (I hope! :-)).

Two Exceptions:

Last class (06/18) is an online presentation of the final report. If you have problems with live presentation (time zones, etc), lemme know.

Final exam (06/25) will be live (online or in person, depends on covid situation in June). Tell me if you have timezone problems.

Course Format

Student / Teacher communication

- Office hours: Friday, 15:15-18:00, TEAMs meeting.
- manaba Forums: This is the preferred way for asynchronous communication, since all students can see the question. Other students are highly encouraged to answer or add their opinions.
- e-mail: If you need to ask a private question.

One goal of this course is to shed light on the "Dark Curriculum". Please feel free to ask any questions at all about life as a scientist / academic / etc.

Course Materials

Required materials are posted on the "manaba" system. If you want to follow the course, but not take credit, you can access the manaba materials using the self-registration number: 4054723.

If you cannot access manaba, the course is also available on the following github repository: (not official) `https://caranha.github.io/ExperimentDesignCS/`.

Report submission, and some recommended readings are only available on manaba.

Course Materials

Lecture Notes

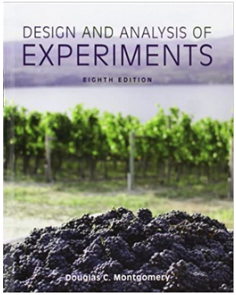
The main materials for this course are these lecture notes. Make sure to read them and ask questions if anything is unclear!

The lecture notes were produced based on the "Design and Analysis of Experiments" material produced by Felipe Campelo. You can reach the original lecture notes on: `https://github.com/fcampelo/Design-and-Analysis-of-Experiments`

All good ideas are thanks to Felipe (and other contributors) all errors are my own :-) (Please submit errors as github issues!)

Course Materials

Books and Links



Many topics in this course are explored in much more depth on "Design and Analysis of Experiments", by Douglas C. Montgomery.

In manaba there will be an expanded list of resources for extra study. Make sure to check it out!

Course Schedule

Friday, 15:15–18:00, no "change days"

- 4/09 : Introduction, What is Experimentation (Today)
- 4/16 : Point and Interval Indicators
- 4/23 : Inference Testing I
- 4/30 : Inference Testing II
- 5/07 : Golden Week, no Class
- 5/14 : R Tutorial / Review and Discussion of Project I
- 5/21 : Inference Testing III
- 5/28 : Case Studies: Inference Testing in CS papers
- 6/04 : Sample Size and Experiment Power
- 6/11 : Final Review
- 6/18 : Project II presentation
- 6/25 : Final Exam

Grading

Two reports (R1, R2), and a final examination (E). Each graded from 0 to 100. The final Grade (FG) is:

$$FG = 0.2 * R1 + 0.4 * R2 + 0.4 * E$$

The letter grade for this course follows the Tsukuba standard
($< 60 : D; < 70 : C, < 80 : B, < 90 : A$)

Grading

Final Examination

- Covers the topics of the entire course.
- Must be answered in English.
- You may prepare **one A4 page of handwritten notes (both sides)**, and use it on the test.
  - The notes have no fixed format, and can be in any language.
  - The notes must include your name and student ID, and must be turned in with the exam. The notes will not be graded.
- No other consultation is allowed in the exam.
- The exact format of the exam (online or in person), will be defined in June.

Grading

Reports

Two "mini-papers". The student must plan, perform, and analyze an experiment of their own choice:

- Choose a scientific question to answer
- Design an Experiment to gather data to answer that question
- Execute the experiment, following the design
- Analyze the data, following the design
- Make a conclusion, based on the analysis of the data

Grading

Reports – More Details

- Report 1: Choose a good experiment for a scientific question, and presenting the data (lectures 1 and 2).
- Report 2: Choose a proper hypothesis pre-data collection, and perform the appropriate inferential statistical test (lectures 1-7).
  - Students must present their reports on lecture 10.
- Topic: The experiment can be on any topic, but using the same topic as your research theme is recommended.
  - If your research includes private data, consult with your advisor first.
- Important: Your experiment will **not** be judged based on the "success" of the experiment. Report your results honestly.

Grading

Reports – Final Details

- Report must be in English.
- Report text must be in pdf format.
- In addition to the PDF, you must also submit all the information necessary to reproduce your experimental results.
  - This depends on the experiment, but tipically include data files obtained from the experiment, and scripts used to process this data, generate figures and statistical tests.
  - Data from the reports will be used only to evaluate the report, and deleted at the end of the course.
- Deadline for the reports will be posted on manaba.

Other Topics:

1 – Computer Science English Program (CSE)

The CSE supports a master degree fully in English. If you plan to take most of your classes in Enslish, do not forget to enroll in the CSE:

Send an e-mail to s-g30@cs.tsukuba.ac.jp with this info:

- Your name (ASCII and Kanji)
- Student ID

For more information, see the orientation material at the "New Student Orientation" course on manaba.

Other Topics:

2 – Self Introduction

- Name: Claus Aranha;
- Country: Brazil;
- Research Topics:
  - Evolutionary Algorithms;
  - Artificial Life;
- Hobbies:
  - Game Programming;
  - Geocaching;
- webpage:

  `http://conclave.cs.tsukuba.ac.jp`

  Ask me anything you want!

About these Slides

These slides were made by Claus Aranha, 2021. You are welcome to copy, re-use and modify this material.

These slides are a modification of "Design and Analysis of Experiments (2018)" by Felipe Campelo, used with permission.

Individual images in some slides might have been made by other authors. Please see the following references for those cases.

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