Modernizing a first course in design of experiments

Peter A. Gao
San José State University

eCOTS 2026

Does your department offer a design of experiments course?

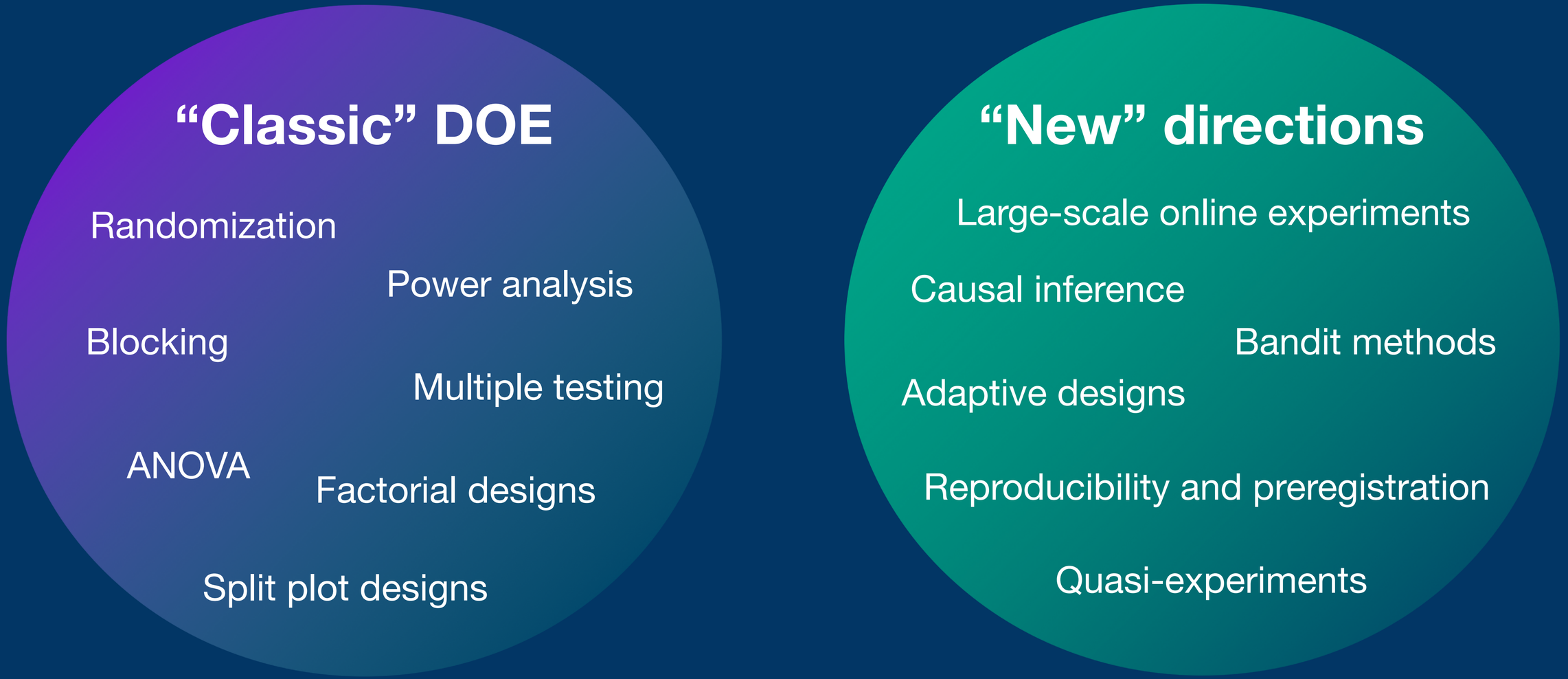
Have you ever taught a design of experiments course? If so, when?

Does the design of experiments course need to change?

MATH 261A at SJSU

- Semester-long (15 weeks) course for MS Statistics and MS Data Science students at a large, public university (Primarily Undergraduate Institution)
- Key texts:
  - *A First Course in Design and Analysis of Experiments* by Oehlert
  - *Applied Linear Statistical Models*, by Kutner, Neter, Nachtsheim, and Li
  - Course notes for Modern Experimental Design taught by Alex Reinhart
- Additional material on causal inference, mixed models, large-scale online experiments
- Final project: Review a published study, evaluate the design, and replicate the analysis and sample size calculations

Concept mapping



Some learning objectives

- Define and evaluate key features of experimental studies (replication, randomization, blocking)
- Analyze experimental data and communicate results orally and in writing
- Understand practical challenges in translating research questions into interpretable findings (external validity, power analysis, multiple testing, preregistration)

What are the most important learning objectives for a design of experiments course?

In other words, what should students be able to do after completing such a course?

Course outline

First ten weeks (traditional design of experiments content):

- Randomization, blocking, and factorial designs
- Comparison of ANOVA and linear regression analysis approaches
- Fixed and random effects

Last five weeks (extensions):

- A/B testing and bandit algorithms
- Observational studies and quasi-experiments

Experiments and methods we discussed

- Small data examples from Oehlert (engineering, chemistry, agriculture)
- Examples from medicine (infant consumption of peanuts, Semaglutide trials, COVID-19 vaccine)
- Examples from social science (nudge experiments, universal basic income trials)
- Large-scale online experiments (Facebook contagion study, A/B testing)
- Quasi-experiments (minimum wage trials, effects of immigration on labor market)

Final project studies

- How do different methods of resistance training affect muscle growth? (Wolf et al. 2025)
- Do people respond differently to AI-generated art compared with human-made art? (Zhang et al. 2026)
- How can public health communications affect individuals' likelihood of spreading misinformation? (Rasmussen et al. 2024)

Reflections on the semester

- The nitty gritty details still matter—but how do we make them interesting? How do we make these stick?
- Introducing material on large scale online experiments and causal inference was largely successful and can offer another perspective on key principles of design (covariate balancing and randomization)
- Final project gave students opportunity to synthesize lessons from the semester—How can we incorporate more “whole pipeline” activities?

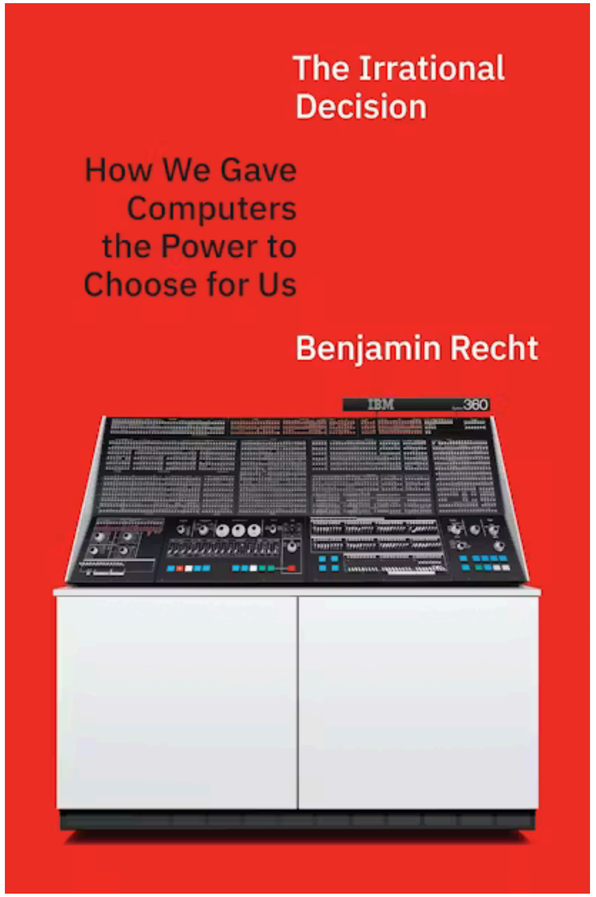
Does the design of experiments course need to change?

What, if anything, would you prioritize? What, if anything, would you drop?

“***Randomized trials are a means of regulation***.

The preposterous eyeglasses trial reinforces that the main goals of randomized trials are policy evaluation, not scientific identification of cause and effect. The question is rarely ‘Does this intervention work?’ *but rather* ‘Is this intervention worth it?’

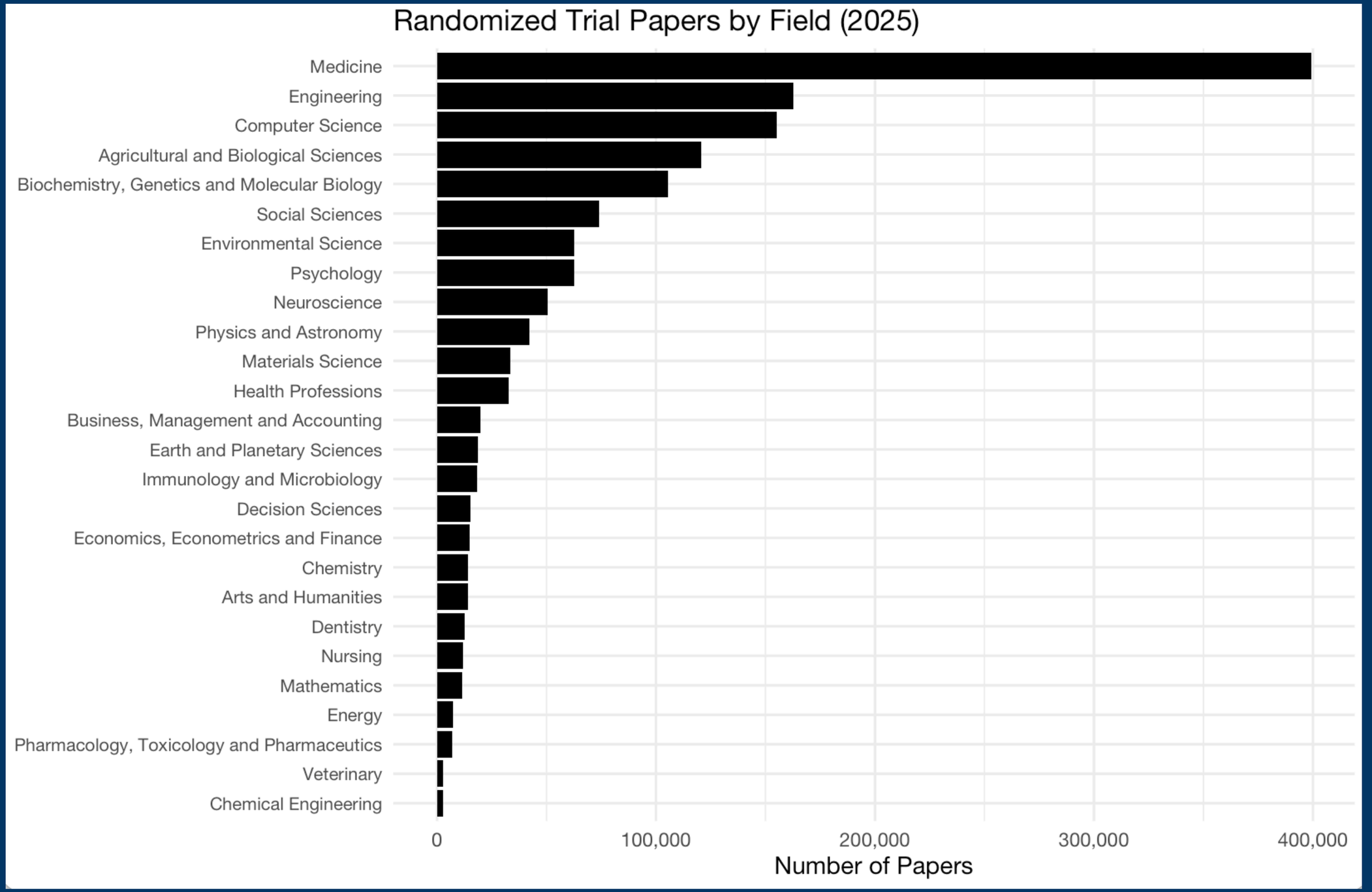
From its inception, the FDA demanded a regulatory mechanism to test whether drugs were safe and effective before making them legal. They wanted to know if the benefits outweighed the risks. In development economics and social science, the goal of a trial is to determine whether a government should allocate funding toward this intervention. … In technology companies, randomized trials are now widely used to determine whether it is worth adopting pieces of code.”



What should our students learn about the role of randomized experiments in society today?

In what fields are randomized experiments being used in 2026?

Can we share examples of recent papers (ideally with code and data available)?


Randomized Trial Papers by Field (2025)
Medicine
Engineering
Computer Science
Agricultural and Biological Sciences
Biochemistry, Genetics and Molecular Biology
Social Sciences
Environmental Science
Psychology
Neuroscience
Physics and Astronomy
Materials Science
Health Professions
Business, Management and Accounting
Earth and Planetary Sciences
Immunology and Microbiology
Decision Sciences
Economics, Econometrics and Finance
Chemistry
Arts and Humanities
Dentistry
Nursing
Mathematics
Energy
Pharmacology, Toxicology and Pharmaceutics
Veterinary
Chemical Engineering
0
100,000
200,000
300,000
400,000
Number of Papers

Share your own resources

Link will be provided to a collaborative resource list, but feel free to put suggestions in the chat as well!