Design of Experiments

Dr. Reagan Mozer | Bentley University | MA255 Spring 2026

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Office Hours: TBD *(or by appointment)*

Class Meetings: M/Th. 11:00am - 12:20pm
Jennison Hall 415

Overview

"*To consult the statistician after an experiment is finished is often merely to ask him to conduct a post mortem examination. He can perhaps say what the experiment died of.*" - Sir R. A Fisher

This course covers planning, conducting, and analyzing statistically designed experiments with an emphasis on hands-on experience. Standard designs studied include factorial designs, block designs, latin square designs, and repeated measures designs. Other topics covered include the principles of design, randomization, data collection, and analysis of variance models. Specific applications will stress cost savings and policy making; multiple examples will be drawn from marketing, psychology, and industrial science.

Learning Objectives

Students should become proficient in the statistical design, analysis, and critique of experiments. In particular, students should be able to:

- recognize standard experimental designs from descriptions of how the experiments were run;
- determine the appropriate statistical analysis in standard design situations;
- choose appropriate experimental designs for standard experimental situations, based on information about the conditions and goals of the experiment;
- recognize when poor designs or analyses were used;
- diagnose unmet statistical assumptions and, when necessary, make appropriate adjustments;
- communicate the results of an experiment and the implications of statistical findings within a given business context.

Course Materials

Textbooks

References and readings related to course topics will be based primarily on the two texts listed below.

- *Applied Linear Statistical Models* (5th ed.) by Kutner, Nachsheim, Neter, and Li.
  - As far as I can tell, this text is out of print. However, PDF copies of all relevant chapters will be made available on Brightspace. There are also copies of the full text floating around online.
- *Design and Analysis of Experiments and Observational Studies using R* by Nathan Taback.
  - **Free** e-book available at https://designexptr.org/. Print copies can be purchased on Amazon.

Throughout the semester I will indicate what sections of the texts correspond to the topics discussed in class. When appropriate, I may also post other supplemental materials relevant to course topics on Brightspace. Readings are optional in the sense that they will not be graded, but they will help you succeed in this course.

Course Website

Announcements, assignments, other course materials will be posted on Brightspace. From time to time, I will also provide references to other materials that may be useful to students, including online readings, tutorials, and/or instructional videos, which will also be made available to students through Brightspace. Lecture slides will typically be posted to Brightspace in advance of each lecture. Note that the lecture slides are intended *accompany* the lecture. They are not designed to be a complete exposition of the material and will not serve as a self-contained reference.

Video recordings of most lectures will be posted to Brightspace each week and will remain available to students throughout the semester. Recordings are for the benefit of students who miss an occasional class or would like to watch the recording for further edification of materials. Solely watching recorded classes is not deemed to be acceptable course participation or completion.

Statistical Computing

Statistical computing is a key part of the class. In class analysis will be conducted in `R` and all course material (code and data) is in `R` format. `R` is free and available for download at http://www.r-project.org. I **strongly encourage** you to install the software as soon as possible and get familiar with simple operations. A list of resources for learning and using R is available on the course website.

Assignments, exams, and grading

Grading Policy

Final grades will be calculated as follows:

Participation & in-class activities	5%
Weekly quizzes	10%
Homework assignments	30%
Midterm exam	25%
Final exam	30%
Total	**100%**

Throughout the semester, grading will conform to the system outlined in the Bentley Student Handbook. Grades are non-competitive (i.e., there is no curve, where the highest score is set as the top of the grading scale). However, *I reserve the right to add points or increase grades uniformly across the class at my discretion* ***at the end of the semester***.

Participation & in-class assignments

Regular attendance and active participation in class are imperative to performing well in this course. While I will not keep track of attendance per se, there will be regular in-class exercises and activities that may be collected and graded for completion and/or accuracy.

Quizzes

There will be a short multiple choice quiz (administered on Brightspace) nearly every week based on the material we are covering that week or the previous week. Quizzes will typically be posted before class each Wednesday and are to be completed outside of class before the next class meeting.

Weekly Labs

There will be weekly data analysis labs designed to give you hands on experience with data analysis using modern statistical software. For each lab, we will spend class time discussing a brief overview of the lab and learning goals and working through a series of exercises. Each lab will also include a set of supplemental exercises designed to reinforce and extend the material introduced in class. These supplemental exercises are practice problems to be completed outside of class and will not be graded; they are simply for your benefit. Accompanying solutions to the supplemental exercises will be posted on Brightspace.

Homework Assignments

There will be four homework assignments throughout the semester. Each assignment will ask you to reflect on experimental design concepts and perform specific tasks and analyses on a given dataset. Note that many homework problems are intentionally open-ended, designed to help you explore and struggle with issues that often manifest in everyday practice.

Policies for completing and submitting homework assignments are as follows:

- Assignments must be submitted to Gradescope and should have a clear and professional presentation. See the homework formatting guidelines posted on Brightspace for additional information.
- ***Late work policy***: Homework assignments can be submitted up to 3 days after the due date, with the following penalties:
  - Up to 24 hours late: 10% penalty
  - 24-48 hours late: 20% penalty
  - 48-72 hours late: 40% penalty

  No homework will be accepted more than 3 days after the posted deadline.
- ***Collaboration policy:*** All homework assignments are to be completed **INDIVIDUALLY**. You are welcome to discuss problems and/or course concepts with other students (and with the teaching staff), but you must write your final answers yourself, in your own words.

Exams

There will be two exams including one in-class midterm covering materials from Weeks 1–6 and a comprehensive final exam administered during the scheduled final exam period. These are tentatively scheduled for **Thursday, March 5** (during our regular class meeting) and **Tuesday, May 5** (during the scheduled final exam period).

Course policies and guidelines

All courses offered at Bentley University reflect our institution's commitment to a set of core values and practices. The links below will take you to full explanations of our policies and procedures related to

accommodations and equitable learning environments. As a student, you are expected to review and be familiar with each of these policies:

- Bentley's honor code and academic integrity system
- Equity and bias reporting forms and procedures
- Student disability accommodations
- Religious observances
- Bentley's core values

AI Policy

In this course, we recognize the growing importance of generative AI tools like ChatGPT in both academia and in the professional workforce, particularly in fields such as business analytics. These tools can be valuable in enriching the learning experience and deepening one's understanding of course concepts. However, it is essential to delineate the appropriate use of AI within the academic context. While AI can supplement and enhance individual learning (and I *encourage* you to use it for these purposes!), it must not be used as a substitute for in-class learning or as a means to complete coursework on behalf of the student. Any use of AI to generate content that is presented as the student's original work will be considered a serious academic violation and will be reported to the Office of Academic Integrity.

If you choose to utilize AI to assist with assignments or course work, you MUST include an acknowledgments page explaining the extent and nature of the AI's involvement. At a minimum, this should include:

(a) a description of precisely which AI tools were used (e.g., ChatGPT 4.0, Bard free version), and
(b) a brief explanation of how the tools were used (e.g. to brainstorm, explain a concept, edit writing, debug code, etc.)

Note: Failure to properly acknowledge the use of AI (when used for assignments or other student work) will be treated as an academic integrity violation and will be reported and sanctioned accordingly.

Dissemination of course materials

All course materials are for teaching purposes for this course during this term only. You may not reproduce these materials to distribute outside of class. Lectures and course materials, including PowerPoint presentations, outlines, tests, and similar materials are protected by copyright even if there is no copyright notice on the material. You may take notes and make copies of course materials for your own use. You may not reproduce or distribute these materials publicly, without the instructor's express written consent. Any suspected violations of this policy are regarded as acts of academic dishonesty and will be reported through Bentley's Academic Integrity System.

Diversity and Inclusion

As an instructor, I recognize that every student has their own perspectives and life experiences that they bring with them into the classroom and I will do my best to create a space for learning that is safe and accessible for all. It is my intent to present materials and activities that are respectful of diversity: gender identity, sexuality, disability, age, socioeconomic status, ethnicity, race, nationality, religion, and culture. Throughout the semester, I welcome (and encourage!) your feedback on how to foster a positive and inclusive environment in this class. Any and all suggestions will be appreciated and given serious consideration.

In addition, I invite all students to inform me of any personal and/or professional courtesies that I may be unaware of. If you have a name and/or pronouns that differ from those that appear in my course roster, please let me know so that I may address you appropriately. If something said in class (implicitly or explicitly) by myself or another student that has made you feel uncomfortable, please talk to me about it. Finally, if you feel your academic performance is being impacted by your experiences outside of class, please don't hesitate to talk with me. If you prefer to speak with someone outside of the course, your academic dean is also an excellent resource.

Mathematics Learning Center

The Mathematics Learning Center (MLC) provides drop-in tutoring to undergraduate and graduate students enrolled in mathematics or statistics courses at Bentley. The goal is to have students leave a tutoring session with an increased understanding and confidence in their own ability to do mathematics. During the academic year, the center is open most days and evenings. Students can get help with all 100-level undergrad math courses. In addition, **there are selected hours in which students may get help with math electives including this one**. Computer assistance as it relates to a mathematics course is also provided. Please check the MLC website for the hours of operation and tutor/course schedule.

Adjustments to the course

The scope, timing, and due date/time of any assignments, projects, homework, exams, or any other required work may be adjusted by the instructor as needed to maximize learning opportunities for students and/or better serve the goals of the course. The syllabus may likewise be modified at the discretion of the instructor. Any adjustments will be communicated to students in class and on Brightspace with as much advance notice as possible.

Schedule & Topics

Disclaimer: Schedule is subject to change, contingent on mitigating circumstances and the progress we make as a class. Students are encouraged to attend lectures and check the course website for updates.

Wk.	Dates	Topics	Reading		Deliverables
			ALSM	*DAE*	
1	1/22	Course overview, intro to experimental design	Ch. 15	———	
2	1/26, 1/29	Fundamentals of experimental design, review of key statistics concepts	———	Ch. 1–2	Quiz 1
3	2/2, 2/5	Single-factor designs: randomization and randomization-based inference	Ch. 16.9	Ch. 3, 7.1–7.3	Quiz 2
4	2/9, 2/12	Single-factor designs: parametric inference and model checking	Ch. 16, 18	Ch. 5.1–5.5	Quiz 3 **HW1 due**
5	2/16, 2/19	Post-hoc analysis	Ch. 17	Ch. 5.6	Quiz 4
6	2/23, 2/26	Power, effect size and sample size planning	Ch. 16.10–16.11	Ch. 4	Quiz 5 **HW2 due**
7	3/2, 3/5	Review & **Midterm Exam**	———	———	
_	3/9, 3/12	*Spring Break (No class)*	———	———	
8	3/16, 3/19	Randomized factorial designs	Ch. 19, 24	Ch. 6.1–6.3	Quiz 6
9	3/23, 3/26	Analysis of covariance (ANCOVA)	Ch. 22	———	Quiz 7
10	3/30, 4/2	Blocking designs	Ch. 21	Ch. 5.8–5.12	Quiz 8 **HW3 due**
11	4/6, 4/9	Repeated measures designs	Ch. 27.1-27.2	`lme4` vignette	Quiz 9
12	4/13, 4/16	Mixed repeated measures and related designs	Ch. 25, 27.3	`lme4` vignette	Quiz 10
13	4/23	Exploratory and screening designs	Ch. 29	Ch. 6.4–6.8	Quiz 11 **HW4 due**
14	4/27, 4/29	Course wrap up and final review (Note: 4/29 is Monday schedule)	———	———	
_	5/5	**Final Exam (3:00 - 5:00 pm)**			