ESRM 6553: ADV. MULTIVARIATE

Spring 2024, Mondays, 5:00-7:45PM, Classroom GRAD 0229

Dr. Jihong Zhang

General Information

- **Course Code:** ESRM 6553
- **Course ID:** 026376
- **Course time and location:** Mon 17:00-19:45; GRAD 229
- **Instructor:** Jihong Zhang
- **Contact Information:** jzhang@uark.edu
- **Office Location:** GRAD 0109
- **Office Hours:** Tu 1:30-4:30PM
- **Office Phone**: +1(479)-575-5235
- **Classroom:** GRAD 229
- **Semester:** Spring 2024
- **Credits:** 3 credit hours

Course Topics

1. **Introduction to Bayesian Statistics**
    - Likelihoods;
    - Probability distributions, such as priors and posteriors;
    - Theorectial foundations of Bayesian infernce;
2. **Bayesian Inference and Computational Methods**
    - Markov Chain Monte Carlo (MCMC) estimation procedures;
3. **Bayesian Modeling Evaluation**
    - Model specification, estimation, and testing.
    - Model fit and model comparison, such as convergence diagnostics, posterior predictive checks, information criteria
4. **Bayesian Modeling**
    - Estimating and making inferences from psychometric models such as Confirmatory Factor Analysis (CFA) or Item Response Theory (IRT) models
5. **Advanced Topics in Bayesian Multivariate Analysis**
    - Bayesian networks.
    - Multilevel/Hierarchical models, mixture models.
    - Missing data, non-normal data.

Course Description

This course offers an in-depth exploration of multivariate statistics within the context of Bayesian inferences. Bayesian statistics have been widely used in public health, education, and psychology. Bayesian techniques are increasingly used in Artificial Intelligence and Brain models for decision-making under uncertainty. Designed for graduate students in educational statistics and research methods, it focuses on the theoretical underpinnings

and practical applications of Bayesian approaches in psychometric modeling. Prerequisites include basic knowledge of multivariate statistics and psychometrics.

Course Objectives

Upon completion of ESRM 6553 - Adv. Multivariate, students will:

1. Comprehend fundamental concepts and principles of Bayesian multivariate analysis;
2. Articulate the rationale of Bayesian approaches to data analysis and statistical inference;
3. Compare Bayesian inference to Maximum Likilihood Estimation (MLE);
4. Develop conceptual and mathematical Bayesian literacy, as well as computer software skills (e.g., R, Stan, or JAGS) required to conduct Bayesian data analyses in educational research;
5. Gain technical foundations necessary to be contributors to applied and methodological research that use Bayesian methods;
6. Conduct analyses on empirical data, interpret results, and communicate work in written and oral presentations.

Course Format

- Lectures for theoretical understanding.
- Hands-on sessions with statistical software.
- Group discussions and presentations.
- Research project guidance.

Prerequisite Knowledge

It is assumed that students have has solid statistical training up to and including topics in multivariate statistics (ESRM 6413, 6423, and 6453). In addition, it is assumed you are familiar with R programming (python or SAS are fine). SPSS may not be sufficient for this course.

How to Be Successful in This Class

1. Come to class ready to learn.
2. Complete the out-of-class exercises prior to each class.
3. If you become confused or don't fully grasp a concept, ask for help from your instructor
4. Know what is going on: keep up with email, course announcements, and the course schedule.
5. Try to apply the information to your area of interest — if you have a cool research idea, come talk to me!

Course Materials

Required Materials

1. **Primary Text:** Richard McElreath (2019), *Statistical Rethinking: A Bayesian Course with Examples in R and Stan*. Free to download it online.
2. **Primary Text:** Levy, Mislevy (2016), *Bayesian Psychometric Modeling*. Chapters will be uploaded before class.

Optional Materials

- Kaplan, D. (2014), Bayesian Statistics for the Social Sciences. New York: Guilford Press.
- Gelman, A., Carlin, J. B., Stern, H. S., and Rubin, D. B. (2020), Bayesian Data Analysis 3rd edition. Chapman and Hall.
- Andrew Gelman's Website for an unfiltered, stream of consciousness Bayesian commentary
- **Supplementary Texts:** Stan User's Guide

Software

- R and R packages
- Stan is gaining in popularity and has an avid user community. To use Stan in R, you need to download RStan package. Here is the tutorial of installing RStan.
- (Optional) Mplus, JAGS, WinBUGS

Assignments

Projects

Students will complete a project utilizing your knowledge learnt from the class. You may work individually. I will provide data and questions for this project OR you can use data that is of interest to you in your GA position or dissertation research. The primary objective of the research project is to facilitate the application and understanding of concepts learned in this course.

There will be a short project proposal due around week 12 - it can be sooner if you want to get started early. Required for this proposal is an NCME-type conference proposal (800 words maximum). Please see Individual Paper Presentations for more details

Typical components of the research proposal include:

- Title (no more than 12 words)
- Summary of research (no more than 800 words)
  - Background of research
  - Research questions/hypotheses
  - Method (Data, Analysis Plan)
  - Preliminary findings
  - References/Table/Figure

Brief quiz

At the commencement of each class session, a brief quiz consisting of one to three questions will be administered. These quizzes are intended for formative assessment purposes only and will not contribute to your overall score. However, regular attendance is essential, as it will ensure full credit in the final grading process.

Grading

1. Brief quiz: 60%
2. Project Presentation: 20%
3. Project Proposal: 20%

$$Score = Q * 0.6 + Pres * 0.2 + Prop * 0.2$$

Grades will be assigned based on the following scale:

- A = 94-100;
- A- = 90-93;
- B+ = 87-89;
- B = 83-86;
- B- = 80-82;
- C = 70-79;
- F = < 70;

Academic Policies

AI Statement

Specific permissions will be provided to students regarding the use of generative artificial intelligence tools on certain graded activities in this course. In these instances, I will communicate explicit permission as well as expectations and any pertinent limitations for use and attribution. Without this permission, the use of generative artificial intelligence tools in any capacity while completing academic work submitted for credit, independently or collaboratively, will be considered academic dishonesty and reported to the Office of Academic Initiatives and Integrity.

Academic Integrity

You are responsible for reading and understanding the University of Arkansas' Academic Integrity Policy. You are expected to complete all assignments and exams with the highest level of integrity. Any form of academic dishonesty will result in a failing grade for the course and will be reported to the Office of Academic Integrity. If you have any questions about what constitutes academic dishonesty, please ask me.

Emergency Preparadness

The University of Arkansas is committed to providing a safe and healthy environment for study and work. In that regard, the university has developed a campus safety plan and an emergency preparedness plan to respond to a variety of emergency situations. The emergency preparedness plan can be found at emergency.uark.edu. Additionally, the university uses a campus-wide emergency notification system, UARKAlert, to communicate important emergency information via email and text messaging. To learn more and to sign up: http://safety.uark.edu/emergency-preparedness/emergency-notification-system/

Inclement Weather

Each faculty member is responsible for determining whether or not to cancel class due to inclement weather. If you have any questions about whether or not class will be held, please contact me. If I cancel class, I will notify you via email and/or Blackboard. In general, students need to know how and when they will be notified in the event that class is cancelled for weather-related reasons. Please see here for more information.

Academic Support

A complete list and brief description of academic support programs can be found on the University's Academic Support site, along with links to the specific services, hours, and locations. Faculty are encouraged to be familiar with these programs and to assist students with finding an using the support services that will help them be successful. Please see here for more information.

Religious Holidays

The university does not observe religious holidays; however Campus Council has passed the following resolution concerning individual observance of religious holidays and class attendance:

> When members of any religion seek to be excused from class for religious reasons, they are expected to provide their instructors with a schedule of religious holidays that they intend to observe, in writing, before the completion of the first week of classes.

Schedule

Weekly breakdown of topics and readings:

Week	Date	Topic	Reading
1	01/15	No Class	
2	01/22	Introduction to Bayesian Statistics Part I	SR[1] Chapter 1
3	01/29	Introduction to Bayesian Statistics Part II	SR Chapter 2

[1] SR: *Statistical Rethinking 2ed Edition* by Richard McElreath

Week	Date	Topic	Reading
4	02/05	Bayesian Inference and Computational Methods I	SR Chapter 3
5	02/12	Bayesian Inference and Computational Methods II	
6	02/19	Bayesian Inference and Computational Methods III	SR Chapter 9.2 & 9.3
7	02/26	Bayesian Modeling Evaluation I: Model diagnosis	SR Chapter 7.1 & BPM[2] Chapter 10
8	03/04	Bayesian Modeling Evaluation II	SR Chapter 7.4 & 7.5
9	03/11	Bayesian Modeling I: CFA	BPM Chapter 9
10	03/18	Spring Break	
11	03/25	Bayesian Modeling II: IRT	BPM Chapter 11
12	04/01	Bayesian Modeling III: CDM	BPM Chapter 13
13	04/08	Advanced Topics I: Non-normal data	
14	04/15	Advanced Topics II: Multilevel	SR Chapter 11
15	04/22	Advanced Topics III: Missing Data, Measurement Error	SR Chapter 15
16	04/29	Student Presentations	

Academic calendar for Spring 2024: Here

[2] BPM: *Bayesian Psychometric Modeling* by Levy & Mislevy (2016)