EDUC 8230: Quantitative Methods in Educational Research
Fall 2007

Class: Wed 9:00-11:30 EDUC 143
Lab: Wed 2:00-3:00 EDUC 334

Instructor

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Course Overview

Imagine that you are having lunch with a friend and you overhear the following snippet of a conversation between two teachers at a nearby table:

> TEACHER 1: It's just ridiculous. I'm all for accountability, but there's only so much a teacher can do in a huge class with 35 students. Just look at test prep companies like *The Princeton Review* or *Kaplan*. They limit their courses to 20 students and after just a couple months of coaching students are improving their test scores by 100 points or more.
> TEACHER 2: Yeah, but those coaching companies make you pay for those small classes—don't they charge something like $1,000 to take a course?
> TEACHER 1: Look, it's the same principle. Sure, lowering class sizes will cost money—but if people want kids to learn, they have to be willing to pay the price.

Now, there are many implicit and explicit claims being made in this conversation. As you hear them, you may be apt to agree or disagree with some or all of them. Why? By the end of this two-semester course, I hope you will be able to take statements like these and (a) identify the questions that could be investigated empirically with a research project, (b) conceptualize one or more potential research designs you might employ to address the questions, (c) think critically about the evidence (e.g. data) you would want to gather, and (d) choose an appropriate statistical model to describe your results, and, when appropriate, make statistical inferences.

> "*Statistics is the art of making numerical conjectures about puzzling questions*."—Freedman, Pisani and Purves (2007)

In this course, I want you to view statistics as a means of formalizing research designs and analyzing the data that these designs produce with the intent of finding answers, in the words of Freedman, Pisani & Purves, to "puzzling" questions. Though I will be introducing you to some abstract concepts, as much as possible these concepts will be contextualized and illustrated with examples taken from the educational research literature.

Here are some of the research questions that will serve as the context for many of our discussions:

- Do high stakes testing programs lead to cheating among teachers?
- Why did the U.S. crime rate drop in the early 1990s?
- Why was there a cholera epidemic in London during the mid-19th century?
- What are the effects of commercial coaching programs on the performance of students taking college admissions tests?
- What is the effect of redeveloping inner-city school playgrounds on the physical activity of inner-city schoolchildren?
- How does redeveloping school playgrounds lead to a change in physical activity?
- What is the effect of reducing class size on the academic achievement of elementary school students?
- How does reducing class size lead to better learning experiences for students?

All of the questions above examples of causal research questions. That is, to answer each question, a researcher must make one or more causal inferences. In this course you will be learning about a set of tools that can be used to help answer these sorts of questions. As it turns out, not all causal questions are created equally: we will see that there are certain causal questions for which quantitative research methods are ideally suited. For others, all bets are off, and much hinges upon being persistent, methodical, clever, and a little bit lucky.

Two of the principals contexts for this course are the basis for empirical data sets you will be learning to analyze with statistical software. The first data set is an extract from a study on SAT coaching that I conducted a number of years ago (Briggs, 2004). The second data set is an extract from a famous study on the effects of class size reduction known as the Tennessee STAR Project (Finn & Achilles, 1999; Hanushek, 1999; Krueger, 1999). In addition, you will be exploring the descriptive statistics for school level data available at both the state and national levels as a complement to your Qualitative Methods project in EDUC 8250. This will constitute a formal example of what some people like to call "mixed methods" research.

Required Textbooks

Freedman, D, Pisani, R, & R. Purves. (2007). *Statistics*. (Fourth Edition). New York, NY: W.W. Norton & Company. [FPP]

Levitt, S. D., & Dubner, S. J. (2006) *Freakonomics: A Rogue Economist Explores the Hidden Side of Everything*. (2nd Edition) HarperCollins.

Other Course Readings

(*all articles available electronically from Norlin e-reserves, on the internet or on CULearn*)

Briggs, D. (2004). Evaluating SAT coaching: gains, effects and self-selection. In: *Rethinking the SAT: Perspectives Based on the November 2001 Conference at the University of California, Santa Barbara*, R. Zwick, ed., RoutledgeFalmer.

Briggs, D. & Wiley, E. (in press). Causes and effects. In *The Future of Test-Based Educational Accountability*, L. Shepard & K. Ryan (eds). Routledge.

Donohue, J. & Levitt, S. (2001). The impact of legalized abortion on crime. *Quarterly Journal of Economics*, Vol CXVI (Issue 2), 379-420.

Finn, J. & Achilles, C. (1999). Tennessee's class size study: findings, implications, misconceptions. *Educational Evaluation and Policy Analysis* 21(2), 97-110.

Hanushek, E. (1999). Some findings from an independent investigation of the Tennessee STAR experiment and from other investigations of class size effects. *Educational Evaluation and Policy Analysis* 21(2), 143-164

Holt, J. (2005). Book review: measure for measure. *The New Yorker*. Jan 24 & 31, 2005, 84-90.

Johnson, S. (2006). *The Ghost Map*. New York: Riverhead Books. (selected sections, optional)

Kaplan, J. (2005). The effectiveness of SAT coaching on math SAT scores. *Chance*, 18(2), 25-34.

Krueger, A. (1999) Experimental estimates of education production functions. *Quarterly Journal of Economics*. May, 1999. (optional)

Shadish, W., Cook, T., and D. Campbell. (2002). *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. Boston, CA: Houghton-Mifflin. Ch. 1.

Smyth, F. (1990). SAT Coaching: What really happens and how we are led to expect more. *The Journal of College Admissions* 129(Fall): 7-17.

Snow, J. (1855). *On the Mode of Communication of Cholera*. Available online at http://www.ph.ucla.edu/epi/snow/snowbook.html

Wainer, H. & Robinson, D. (2003). Shaping up the practice of null hypothesis significance testing. *Educational Researcher*. October 2003, 22-30.

Course Schedule

Introduction and Overview

- Ed's 4 Circles: The Real World and The Research World
- Derek's 3 Types of Causal Questions
- Course Syllabus

Readings:
Freakonomics, Introduction, Ch 1 & 4

PART 1: DESIGNING A QUANTITATIVE RESEARCH STUDY

Readings:
FPP, Ch 1-2
Briggs & Wiley, Causes and effects

TOPIC 1.1
An Introduction to Causal Inference

- What are the three different elements that comprise any causal inference? How do the three elements differ?
- How is looking for the cause of an effect different from looking for the effect of a cause?
- What is the relationship between a counterfactual and a control group?

TOPIC 1.2
Experimental Design and Threats to Internal Validity

- What is the fundamental distinction between a randomized experiment and an observational study (aka "quasi-experiment")?
- What are threats to the internal validity of a research study?

Readings:
Shadish, Cook & Campbell (2003), Ch. 1 (pp. 1-32)
Donohue & Levitt (2001) The impact of legalized abortion on crime. *QJE.*
Snow, J (1855) *On the Mode of Communication of Cholera,* Parts 1-3 (pp. 1-98)

http://www.ph.ucla.edu/epi/snow/snowbook.html
Johnson, S. (2006) *The Ghost Map* (optional)

Assignment: Problem Set 1 [Topics 1.1 and 1.2]

Note: TOPICS 1.1 and 1.2 will be undercurrents that run throughout this course in this semester and the next. We will return to them many times from week to week, so don't worry if they seem a bit muddled at this stage.

PART 2: USING DESCRIPTIVE STATISTICS IN EDUCATIONAL RESEARCH

Readings:
Effects of Commercial Test Preparation (Coaching)
Smyth (1990) [focus on pp. 12-16]
Briggs (2004)
Kaplan (2005)

TOPIC 2.1
Describing Individual Variables Graphically & Numerically

- What are different kinds of quantitative variables?
- Why is it useful to examine the distribution of a variable?
- How are bar graphs, pie charts, stem plots and histograms used to communicate quantitative information?
- What are measures of the central tendency of a variable?
- What are measures of the spread of a variable?

Readings: FPP, Ch. 3-4

Assignment: Problem Set 2 [Topic 2.1]

TOPIC 2.2
More Sophisticated Summaries of a Variable: The Normal Distribution

- How do you standardize a continuous variable?
- What are the key properties of the normal distribution?

Readings: FPP, Ch. 5

TOPIC 2.3
Measurement Error

Readings: FPP, Ch. 6

Assignment: Problem Set 3 [Topics 2.2 and 2.3]

TOPIC 2.4
Analyzing Relationships Between Two Variables: Scatterplots & Correlation

- What is the difference between positive and negative associations?
- How can correlation be visualized graphically?
- How is the correlation coefficient calculated?
- What is an example of an ecological correlation?
- What is an example of restriction of range?

Readings: FPP, Ch. 8-9

Assignment: Problem Set 4 [Topic 2.4]

TOPIC 2.5
Simple Linear Regression

- What does it mean to regress one variable on another?
- What is the key criterion for fitting a regression line?
- What is regression to the mean and when does it happen?
- What is the Root Mean Square Error (RMSE) of a regression line?
- What are the assumptions being made in using a regression line to predict the values of one variable from another?
- What are residuals and how can they be used as a diagnostic tool?

Readings: FPP, Ch. 9-11; Holt (2005)

Assignment: Problem Set 5 [Topic 2.5]

MIDTERM [Take-home: Target date is mid-October]

PART 3: STATISTICAL INFERENCE IN EDUCATIONAL RESEARCH

Readings:
Class Size Reduction and the STAR Experiment
Achilles & Finn (1999)
Hanushek (1999)
Krueger (1999) [optional]

TOPIC 3.1
An Introduction to Statistical Inference and Probability

- When is statistical inference important for making causal inferences?
- What is the difference between a parameter and a statistic?

- What is the difference between the multiplication rule and addition rule for finding the probability of a series of events?
- What is the distinction between independent events and conditionally independent events?

Readings: FPP, Ch. 13-14

Assignments:
Problem Set 6 [Topic 3.1]
The Memo Project

TOPIC 3.2
Chance Variability

- What does it mean for something to be called a random variable?
- What does the law of averages say and why is it so often misinterpreted?
- What is a the difference between an expected value and an observed value?
- What does a standard error quantify?

Readings: FPP, Ch. 16-18

Assignment: Problem Set 7 [Topic 3.2]

TOPIC 3.3
Sampling Distributions

- How is a probability histogram different from a histogram of an observed variable?
- What is the central limit theorem and why is it important to making statistical inferences?
- What is a confidence level and what determines how is it chosen?
- How is the standard normal curve used to establish a confidence interval?

Readings: FPP, Ch. 19-21, 23

Assignment: Problem Set 8 [Topic 3.3]

First Draft of Memo Assignment due in first week of November

TOPIC 3.4
Conducting Tests of Statistical Significance: The Basic Approach

- What are the steps in testing for statistical significance?
- What is the interpretation of a p-value?
- How does the choice of a significance level affect the conclusion from a test of significance?
- What is the relationship between a standard error and a z-statistic or t-statistic?
- What are the key assumptions being made about how your sample was generated?

Readings: FPP, Ch. 26

Assignment: Problem Set 9 [Topics 3.5 and 3.6]

TOPIC 3.5
Comparing Two Sample Averages

- What is the distinction between a standard error for an average and a standard error for a difference?
- What are some examples of two independent samples? two dependent samples?
- What is the "population" and what is the "sample" in the box model for a randomized controlled experiment?

Readings: FPP, Ch. 27

TOPIC 3.6
The Chi-Square Test

- How does the Chi-Square sampling distribution compare to the *z* or *t* sampling distributions?
- How is the Chi-Square statistic used to test for independence between two categorical variables?

Readings: FPP, Ch. 28

TOPIC 3.7
When is Statistical Inference Sensible?

- What is the difference between statistical significance and practical significance? When is one more important than the other?
- How do we quantify and interpret an *effect size*?

Readings:
FPP, Ch. 29
Wainer & Robinson (2003)

Final Draft of Memo Assignment Due

Review for Final Exam

Final Exam passed out [Take home: Due by 4:00 pm, Dec 15th]

CULearn

I will try to make all lecture notes, presentations, handouts, data sets, etc. available to you on CUlearn. You can access this by going to https://culearn.colorado.edu and logging in. I recommend that you check this site within about 15 minutes of the start of each class for any lecture notes or presentation slides I may have posted for your convenience. I will also bring handouts of presentation slides to class for your note-taking convenience, but they will be six slides to the page.

Problem Sets

The problem sets I assign are intended to reinforce the concepts presented in your readings and discussed in class. Many of the exercises give you a chance to work on your conceptual understanding of statistics. Other exercises in the problem sets are intended as lab exercises to develop your familiarity with data analysis using statistical software.

You will always be given at least one week to complete any assigned problem set. I encourage you to work together on problem set assignments, as this is often an excellent way to learn statistics. However, you must turn in your own work. Please, whenever possible, show all your work on problem set exercises. Typically the final answers are much less important than how you arrived at them. Finally, neatness matters! No credit will be given to problem sets that are illegible or unintelligible. All problem set responses are to be uploaded electronically to an assignment "drop-box" via CULearn.

Problem sets will be scores on a 4 point scale:
4 = Generally nailed it.
3 = One major or several minor misconceptions evident or minor computational errors.
2 = Major misconceptions evident or doesn't support answers w/ evidence (show work).
1 = Not all problems completed, major misconceptions evident.

Generally, if you're getting some combination of 3s and 4s on your problem sets this will translate into an "A" grade, while a combination of 2s and 3s will be a "B" and so on. Regardless of what score you get on a problem set, please have a look at any comments I may have embedded elecronically using the "Track Changes" feature in Word, and look over the suggested solution set I will have posted to CULearn.

Weekly Labs

You are required to attend a one hour lab session which will be led by Marie Huchton in EDUC Room 334 every week on Wednesday from 2-3. There are two objectives of these lab sessions:

1) Learning how to use a statistical software package to conduct a data analysis.
2) Getting an empirical context to help you make better sense of statistical concepts.

In addition, the lab is meant to provide you a forum to work with your classmates on problem sets, and raise questions about topics presented in classroom sessions.

Statistical Software

There are at least two options for statistical software you can use to complete the analytical questions contained in each problem set.

SPSS

This is the option students traditionally take. SPSS is a windows driven program that allows the user to analyze data sets through the use of a wide range of statistical procedures. One advantage of SPSS is that it is very user-friendly and can be learned relatively quickly. A second advantage is that your lab sessions will focus primarily on how to use SPSS for your problem sets. A major disadvantage of SPSS is that it is not "open source" and a full version is in fact quite expensive to purchase.

Options:

- All PC and Mac computers in rooms 239 and 332 come with SPSS installed, and this is available for free.
- A student version of SPSS can be purchased online for about $90 through JourneyEd.com: http://www.spss.com/vertical_markets/education/online.htm
- You can rent the full program for 6 months ($46) through e-academy http://www.spss.com/vertical_markets/education/online.htm

The student version of the software has limitations on the size of the data sets it can accommodate, but I will try to make sure the data sets you are given fit within those limitations.

R

If you have any experience with computer programming and are comfortable working with a command line interface, R might be the ideal option for you. A major advantage of R is that is completely open source and free to use. It also happens to be more flexible than SPSS and it's expanding all the time. You can download R at http://cran.r-project.org/

A disadvantage of R is that it is not user friendly and has a rather steep learning curve. If you come into this course with some trepidation about your ability to conduct even a simple statistical analysis, then R is probably not for you. A user's manual for R entitled "An Introduction to R" is included as part of the downloaded R program. This pdf (and others) can be found under the help menu once you've started the program.

The Memo Assignment

After you have taken the midterm exam I will be giving you an assignment to write a five page "memo" in which you are to use what you have learned about descriptive statistics in the first part of the course to add a quantitative component to the qualitative observations you have made at Denver elementary schools as part of the "Learning Landscapes" project you will be doing for EDUC 8250. The aim will be for you to compare the demographic and academic achievement characteristics of the students in the schools you have visited to the characteristics of students in other (a) schools in the Denver School District and (b) schools throughout the state of Colorado. In addition, you will be examining how the schools in Denver and Colorado compare to schools nationally. To accomplish this you will be visiting two principal sources:

The Colorado Department of Education: http://www.cde.state.co.us/
The National Center for Educational Statistics: http://www.nces.ed.gov/

There will be multiple stages to this assignment. First, you will turn in a one-page proposal in which you outline the memo you plan to produce. Next, you will produce a first draft of this memo. This draft will undergo a blind peer review by two of your colleagues in the class. Next, based on the feedback from your peer review, you will revise your memo and turn it in to me along with a letter explaining any changes you have made. I will then provide you with evaluative feedback, and if you wish, you may revise the memo again before the end of the semester. More details on this assignment will be forthcoming after the midterm exam.

Midterm and Final Exam

Both the midterm and the final will be take-home exams that cover material discussed in class and the readings. Both exams are open-book and open-note, but will need to be completed within two and three hours respectively. The final exam is cumulative.

A good way to prepare for these exams will be to carefully work through problem sets and be sure you can answer some of the very general concept questions that are sprinkled throughout the course schedule in this syllabus.

Journal Writing

Following the second class of each week you will be asked to answer the following questions:

1. What new concepts are you thinking about this week as a result of your readings, work on a problem set, and/or classroom lectures, discussions and activities?
2. How do these concepts connect to concepts from the previous week?
3. What has been most helpful to you in developing your understanding of this week's concepts?
4. What has been least helpful to you in developing your understanding of this week's concepts?

Please e-mail me your responses no later than the Thursday following a Friday class. Timely completion of these journal entries will constitute half of your participation grade for the class. The content of individual journal entries will be kept confidential. They are intended to serve as an ongoing formative assessment of your understandings and as feedback to me for what appears to be working and not working in each week's classes.

Grading Policy

Student grades for each semester of this course will be based on the following criteria

Task	Percent of Grade
Problem Sets (9) /Labs	30%
Midterm Exam	20%
Memo Assignment	20%
Final Exam	20%
Participation	10%

Some Suggestions on How to Study/Prepare for this Class

1. Do your assigned readings before the associated topics are presented/discussed in class. Make a note of anything that stands out as particularly confusing to you and be sure to ask questions when the opportunity arises in class.
2. <u>After</u> a topic has been presented/discussed in class, go back and re-read the associated FPP text or other associated reading.

3. In every FPP chapter there are "Exercise Sets" interspersed with the chapter text. Don't skip over these! The answers to these exercises are in the back of the book. Use them to check that you are making sense of what you read.
4. Form a study group with no more than about 3 of your colleagues. (Study groups bigger than 4 are usually too big.) Get together outside of class to work on your problem set assignments and discuss topics that arise in class.
5. Visit Marie or me during office hours—ask questions to your heart's content!

What You Can Expect From Me

Statistics is not an easy subject to teach. Teaching strategies that work for one student may flop for another. With this in mind, you can expect me to use a variety of instructional approaches. Each class will typically include a combination of lecture, discussion, and activities intended to stimulate collaborative learning. I can't promise that each lecture, discussion and activity will be equally effective. I can promise you that I give a great deal of thought to what goes on in our class sessions, and that I will do my best to be receptive to any constructive feedback that you provide me. Many of you have had experience as teachers, and in this regard I hope to learn from you as much as you learn from me. I encourage you to meet with me in office hours, even if only to chat. If you cannot make my office hours, we can arrange for other times to meet.

What I Will Expect From You

For this class to be successful, active participation is a prerequisite. In order for this to happen it is important that you complete, to the best of your ability, all assigned readings and problem sets before they are discussed in class. Classroom presentations and activities are intended to help you grapple with specific topics and concepts that that are fundamental to a successful career as an educational researcher. I expect you to integrate these concepts with the broader range of concepts presented in the textbook and other readings though your work on problem set assignments. To this end, some questions on your problem sets may pertain to material from your readings that has not been discussed in class. This is OK—you may learn as much or more after you "finish" a problem set as you do while working on it.

I expect us to foster a classroom environment that is open to different ideas and opinions. As part of creating a supportive classroom environment, our interactions must be collegial, yet courteous. When one person is addressing the class, please refrain from background conversations. There will be ample time for unstructured conversations in collaborative activities and lab sections.

Reasonable Accommodation

If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed.

Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and www.Colorado.EDU/disabilityservices

Disability Services' letters for students with disabilities indicate legally mandated reasonable accommodations. The syllabus statements and answers to Frequently Asked Questions can be found at www.colorado.edu/disabilityservices

Religious Observances

I will make every effort to accommodate all students who, because of religious obligations, have conflicts with scheduled exams, assignments, or other required attendance, provided advance notification of the conflict is given. Whenever possible, students should give at least two weeks advance notice to request special accommodation. For additional information on this policy, see http://www.colorado.edu/policies/fac_relig.html

Classroom Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to such behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat all students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which they and their students express opinions. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See polices at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

The University of Colorado at Boulder policy on Discrimination and Harassment (http://www.colorado.edu/policies/discrimination.html), the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships applies to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at http://www.colorado.edu/odh

Student Honor Code

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at http://www.colorado.edu/policies/honor.html and at http://www.colorado.edu/academics/honorcode/