Comprehensive Course Syllabus

Statistical Exploration and Description

Course Description:

This course will serve as an introduction to college level statistical thinking. It is built around two broad conceptual themes: 1) Exploring Data: observing patterns, and departures from patterns; 2) Anticipating patterns in advance and introducing probability distributions, random variables and simulation. It will serve as an introductory course to - *Statistical Experimentation and Inference*

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Office Hours (A-157)	By Appointment

Text(s):

Bock, David E., Paul F. Velleman and Richard D. DeVeaux, 2015. *Stats: Modeling the World (4th Ed.)* Boston: Pearson/Addison-Wesley.

Equipment:

1) Ring Binder for handouts, notes, assignments, and group projects.
2) Pencil (with eraser) for all homework, quizzes and tests.
3) TI-89 (or TI-84) Graphing calculator with Stats/List editor.

Technology:

We will be using Microsoft Excel, Fathom, and possibly R along with the Stat/List editor on your graphing calculator for assignments and projects.

Essential Content:

- Exploring and Understanding Data
  - Students will explore and increase appreciation for how data sets can change one's mindset
  - Students will display and describe categorical and quantitative data electronically
- Exploring Relationships Between Variables
  - Students will create scatterplots and describe the direction, strength , and model for any association seen
  - Students will examine the uses and misuses of linear regression
    - Interpret the meaning of a linear regression line and its predictions
    - Re-express data to create linear relationships
    - Correlation versus causation
- Gathering Data
  - Students will understand randomness and use various simulations that model random selection
  - Students will collect samples using appropriate strategies
  - Students will recognize types of bias and potential bias in survey and sample situations
  - Students will recognize and design observational and experimental studies
- Randomness and Probability
  - Students will calculate simple and conditional probabilities
  - Students will know the importance of independent events in calculating probabilities
  - Students will compute expected values of random variables
  - Students will apply the Pythagorean Theorem of Statistics

The outline of the course content below will address the following **Team Goals**:

- Provide students with the opportunities to explore the relationships and inter-connections within the various branches of mathematics and with other disciplines;
- Provide experiences and opportunities that enable students to interpret and to communicate mathematical concepts in both oral and written form;
- Provide experiences through which students will develop and extend their ability to investigate and explore, think critically, solve problems, and apply mathematical tools of thought in a variety of situations using multiple strategies, approaches, and techniques;
- Provide experiences, problems and situations that require students to thoughtfully explore mathematics using appropriate technology as extensions of the mind

In addition, it supports the **Team Unifying Concept** of introducing:
Quantitative literacy: Understanding of numbers, their operations, and the relationships among them is critical for functioning in an increasingly quantitative world. Much of today's information is presented as data in some form. To make intelligent, informed decisions about issues that are based on quantitative information, citizens must be able to read, compute with, understand, interpret, and react to data. In addition, persons expecting to contribute to the general body of knowledge must be prepared to do so through research, which has at its heart experimental design and the implementation, analysis, and interpretation of data. Quantitative literacy is the ability to participate as a member of society in these ways.

The following **Mathematics Learning Standards** are present in the study of statistics. Students will:

- Demonstrate awareness of the interconnectedness of mathematical thought in inter- and intra-disciplinary settings by:
    - understanding that mathematics is a system of interconnected ideas. [SSL-III.B,III.C,IV.C; CCSSM: P7,8; NCTM-9.2]
    - understanding the interaction between mathematics and culture, world history, and other disciplines. [SSL-I.B,II.A,II.B,III.B,III.C,IV.C; CCSSM: P4; NCTM-9.3]
        - Rosling Project
- Understand and employ the power, economy, clarity, and elegance of mathematical representations by:
    - recognizing that mathematical representations carry specific meanings and using mathematical notation correctly to enhance clarity and avoid ambiguity. [SSL-II.B,IV.B; CCSSM: P6; NCTM-10.1]
        - exploration of misleading graphs
        - all written assignments will emphasize the need to clearly communicate in context, with supporting evidence
    - applying a variety of techniques to compare and manipulate mathematical representations. [SSL-I.A,III.B,IV.C; CCSSM: P2,4; NCTM-1.2,1.3,10.2]
        - students will explore the power of various graphics, use various technologies to produce them, and analyze pros and cons
    - recognizing the structure underlying a mathematical representation and utilizing this structure in analysis and problem solving. [SSL-III.B,IV.A,IV.C; CCSSM: P7,8; NCTM-1.1,10.2]
    - selecting an appropriate mathematical representation and demonstrating how it reflects the salient points of the situation it describes. [SSL-I.B,I.D,II.B,III.B,IV.A,IV.C; CCSSM: P4,6; NCTM-2.2,10.2,10.3]
- Use and interpret appropriate mathematical models to represent real-world situations by:
    - choosing an appropriate representation or mathematical model for a given situation. [SSL-I.A,I.B,III.B,IV.A,IV.C; CCSSM: P4; NCTM-2.3,4.1]
    - understanding and explaining the relationship between the model and the given situation. [SSL-I.B,III.A,III.B,IV.A,IV.B,IV.C; CCSSM: P4]
    - analyzing and explaining how variations in the situation will affect the model and how parametric changes in the model would be reflected in the situation it describes. [SSL-I.B,I.D,III.A,III.B,IV.A,IV.B,IV.C; CCSSM: P4]
    - interpreting mathematical results in terms of the situation modeled. [SSL-I.D,III.B,IV.A,IV.C; CCSSM: P4; NCTM-9.3]
    - understand the notion of chance and the use of probabilistic models to quantify and analyze chance. [SSL-IV.A; CCSSM:S-CP5; NCTM-5.4]
- Use data to research questions, make conjectures, inform decisions, and evaluate assertions by:
    - creating and implementing a valid design for research or an investigation. [SSL-I.C,I.D,III.B,IV.A,IV.C; CCSSM: S-IC1,2; NCTM-5.1]

- identifying, selecting, and using appropriate statistical and graphical tools to analyze data in a variety of contexts. [SSL-I.A,III.B,IV.A; CCSSM: S-ID1,2; NCTM-5.1]
- interpreting data and presenting it in such a way so as to make the information contained therein more readily evident. [SSL-I.B; CCSSM: S-ID1,2,6,7; NCTM-5.2]
- carefully critiquing data, the way it was collected, its presentation, and the conclusions drawn from it. [SSL-I.B,I.C,I.D,II.A,IV.A,V.A; CCSSM: S-IC6; NCTM-5.3,8.3]

- Understand and apply discrete mathematical models by:
  - analyzing and interpreting situations using recursive thinking and inductive reasoning. [SSL-I.A,I.B,IV.A; CCSSM: P3, F-IF3, F-BF1,2; NCTM-2.1,2.2,7.3,7.4]
  - demonstrating an understanding of basic counting principles and the situations under which they may be applied. [SSL-I.A,I.D,III.B; NCTM-5.4]
  - understanding and using probability as a way to measure chance events. [SSL-I.A,III.B; CCSSM: S-CP1-3,5-9, S-MD5; NCTM-5.4]
- Use technology to gain insight and obtain different perspectives on problems by:
  - deciding whether to use technology, selecting an appropriate technology for a given situation, and understanding the limitation of the technology. [SSL-I.D,II.A,III.A; CCSSM: P5]
  - using technology to facilitate doing, exploring, and understanding of mathematics. [SSL-II.A,III.A,IV.A; CCSSM: P5; NCTM-6.1]
  - judging the reasonableness of information and answers given by technology. [SSL-III.A,IV.A; CCSSM: P5; NCTM-4.2]

The study of statistics will support the following **Standards of Significant Learning.** (Bulleted items are examples of specific student outcomes and/or activities)

I. Developing The Tools Of Thought

A. Develop automaticity in skills, concepts, and processes that support and enable complex thought.

- Daily in-class problems, book assignments, and formal written assessments develop and assess skills, concepts and processes
- Fluent use of various technologies to support automaticity of concepts is a regular expectation

B. Construct questions which further understanding, forge connections, and deepen meaning.

- Rosling Project – students investigate Gapminder software by posing a question that the Gapminder database can serve to explore. Outcomes include a written paper and oral presentation.
- Library Project – students propose ideas for data collection via sampling in the IMSA IRC. Outcomes include a written paper with full description of the question, sampling techniques and findings.
- Final project proposal – students propose an idea for a capstone project to be completed during the spring semester. Proposals are vetted and revised during fall semester.

C. Precisely observe phenomena and accurately record findings.

- Coke vs. Pepsi
- Body measurements
- Barbie Bungee
- Goldfish
- We're on a Roll Now!
- *These are examples of data collection activities which require measurement of some kind. Results are recorded in Excel, Fathom, or a googledoc sheet for use in analysis.*

D. Evaluate the soundness and relevance of information and reasoning.

- Misleading graphs activity and discussion – students examine graphs for misleading elements and then search to find additional examples and present their findings orally
- All statistical tests require an analysis of the results of the test statistic – students are required to write conclusions based on the context for homework problems, in-class work, and formal assessments.
- *This likely also serves SSL IIA and IIB, as well as CCSSM Practice Standard 3 (Construct viable arguments and critique the reasoning of others)*

III. Extending and Integrating Thought

A. Use appropriate technologies as an extension of the mind.

- Students will actively explore datasets and run statistical tests in Fathom, Excel, and on the TI-89

B. Recognize, pursue, and explain substantive connections within and among areas of knowledge.

- Students will engage in activities, problems, discussions and projects that will involve topics from a host of disciplines, including science, social science, current events, etc.

- Students will design a study for a capstone project that may incorporate various areas of content

IV. Expressing and Evaluating Constructs

A. Construct and support judgments based on evidence.

- This is inherent to the class. All problems pursued require evidence. Homework requires short answers that include judgments based on evidence.
- Class activities require students to reach conclusions based on evidence gathered during the activity.
- Projects require students to reach evidence-based conclusions.

B. Write with power, economy and elegance.

- Students are regularly required to describe data sets and relationships precisely through the context of the problem.
- "Investigative Tasks" require students to present their ideas formally, and assessment is based on content of response, as well as coherence of thought and overall presentation.

Standards for Mathematical Practice (CCSSM)

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.

Course Outline:

Primary textbook:

Bock, David E., Paul F. Velleman and Richard D. DeVeaux, 2015. *Stats: Modeling the World (4th Ed.)* Boston: Pearson/Addison-Wesley.

*note: the units are numbered the way that they are numbered in the primary textbook, denoted BVD.

Introduction:

Time Frame: Week 1
BVD Chapters: 1-2
Topics Covered:

- What is statistics and why do we care?
- What is data?

Unit I: Exploring and Understanding Data

Time Frame: Weeks 2-4
BVD Chapters: 3-6
Topics covered:

- Describing and displaying categorical and quantitative data

    - To include but not limited to: boxplots, dotplots, stem plots, back-to-back stem plots, histograms, frequency plots, and parallel boxplots.
- Introductory discussion of independence
- Summary statistics for quantitative data
- Outliers
- The normal distribution
- The effect of linear transformations to data sets on summary statistics

Unit II: Exploring Relationships Between Variables: Regression
Time Frame: Weeks 5-9
BVD Chapters: 7-10
Topics covered:

- Displaying and describing scatterplots
- Analyzing two-variable quantitative data:
    - Correlation and the coefficient of determination
    - Least-squares regression
    - Slope and *y*-intercept
    - Residuals and residual plots
    - Outliers and influential points
- Transformations to achieve linearity

Unit III: Collecting Data (sampling and experimentation)
Time Frame: Weeks 10-12
BVD Chapters: 11-13
Topics covered:

- Designing surveys via various methods
- Bias in surveys
- Randomization and representative samples
- Experimental design:
    - Control
    - Random assignment of treatment
    - Replication
    - Placebo & blinding
    - Blocking and matched pairs
    - Confounding and lurking variables
    - Statistically significant difference (introduction)
- Observational studies

Unit IV: Probability
Time Frame: Weeks 13-16
BVD Chapters: 15-18
Topics covered:

- Basic probability principles including complement, independence and mutually exclusive
- Simulating probability scenarios
- Addition, multiplication and conditional probability rules
- Random variables:
    - Expected value and standard deviation

    - Rules for transforming and combining random variables
- Binomial and geometric distributions
- Sampling distributions for means and proportions

Assignments: In addition to problems assigned in your textbook you will be involved in activities, explorations, investigative tasks and projects. Selected assignments will be formally written/typed and submitted. You will be expected to read the chapters before class so that we can devote our time to discussion, investigations and activities.

Projects: There will be approximately two small projects, one each quarter. You will do these in small groups.

Quizzes & Tests: Tests will be given after each unit. They may also contain questions from previously studied material.

Grades: Grade distribution for each quarter (subject to change):

- Assignments 25%
- Projects 20%
- Tests 55%

A - 90% or above
B - 80% or above but less than 90%
C - 70% or above but less than 80%
D - less than 70%

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Semester Grade: Semester grades will be averaged using the following weightings:

Cumulative Semester Work	80%
Semester Final Exam	20%