

Course Syllabus
University Studies Program
Southeast Missouri State University

Department of Mathematics

Course No. MA155

Title of Course: Statistical Reasoning

Fall 1999

- I. **Catalog Description and Credit Hours of Course:** This course will introduce statistical ideas to students. The student will reach an understanding of these statistical ideas, be able to deal critically with statistical arguments, and gain an understanding of the impact of statistical ideas on public policy and in other areas of academic study.(3 credit hours)
- II. **Prerequisites:** MA095 or MA096 with a minimum grade of 'C', or two units of high school algebra. Any required developmental mathematics courses must be completed before enrolling in this course.
- III. **Purposes or Objectives of the Course:**
- A. The student will develop the ability to identify and analyze the various representations and misrepresentations of statistical data. (University Studies Objectives: 2,6)
 - B. The student will collect data from a variety of sources, and analyze its validity and effect on society. (University Studies Objectives: 1,2,4,5,6,7,8)
 - C. The student will present statistical data, and give reasons for accepting or not accepting the conclusions drawn from it. (University Studies Objectives: 2,3,7,9)
 - D. The student will gain an appreciation for the complexity of statistical analysis, and how statistical ideas and reasoning ideas are used in public policy and the human sciences, from sociology to medicine. (University Studies Objectives: 2,4,8,9)
- IV. **Expectations of Students:**
- A. Attend class and actively participate in classroom activities and discussions.
 - B. Collect data as assigned and complete assigned homework.
 - C. Read assigned literature, including the texts.
 - D. Complete group and individual projects and present them to the instructor
 - E. Perform adequately on quizzes and tests.
- V. **Course Outline:**
- A. Introduction: Categories of Misuse and Definitions (Objective 2) - 2 Hours
 - 1. What is Statistics?
 - 2. First examples, including: telephone sampling, computer-assisted interviewing, census undercount, data ethics

- B. The Quality of Basic Data (Objectives 1,2) - 2 Hours
- C. Samples (Objectives 1,2) - 9 Hours
 - 1. The practical side of sampling
 - 2. Opinion polls and the political process
 - 3. Data ethics
- D. Experiments (Objectives 1,2) - 6 Hours
 - 1. Why experiment?
 - 2. Design
 - 3. Difficulties: Hidden bias, nonadherers, dropouts
 - 4. Ethics: Fairness, thoroughness, behavioral experiments
- E. Measurement (Objectives 1,2) - 4 Hours
 - 1. Validity: Miscounting, misclassifying, bias
 - 2. The unknowable: Underground economy
 - 3. Disappearing data: Drug use, jobs for youth
 - 4. Scales: Nominal, ordinal, interval and ratio scales
- F. Describing Distributions (Objectives 1,2) - 5 Hours
 - 1. Graphical descriptions: Patterns, deviations, outliers, symmetry
 - 2. Numerical descriptions: average, spread, normal distributions
- G. Relationships (Objectives 1,2) - 4 Hours
 - 1. Cross-classified data: Housing, pay, age discrimination
 - 2. Scatterplots: Test scores, classification
 - 3. Prediction: Causation versus association
- H. The Consumer Price Index (Objectives 1,2) - 4 Hours
- I. Probabilities (Objectives 1,2) - 6 Hours
 - 1. What is probability?
 - 2. Simulation
 - 3. State lotteries
- J. Class examinations - 3 Hours

Total: 45 Hours

VI. Textbooks:

- A. Moore, David S. *Statistics: Concepts and Controversies*. Fourth Edition. New York, NY: W. H. Freeman and Company, 1997.
- B. Spirer, Herbert, Louise Spirer, and A.J. Jaffe. *Misused Statistics*. Second Edition. New York, NY: Marcel Dekker, Inc., 1998.

VII. Basis of Student Evaluation:

- A. Participation/informal assessment (50%) – The students will be required to complete in-class and out-of-class group or individual projects and activities.
- B. Formal assessment (50%) – The students will have in-class tests and quizzes.

Total: 100%

VIII. **Justification for Inclusion in University Studies Program:**

Objective No. 1: *Demonstrate the ability to locate and gather information.*

Emphasis: Significant

Content: Statistical Reasoning places significant emphasis on locating and gathering information both in terms of course content and student assignments. The objective of locating and gathering information in this course is to have students realize how statistics is sometimes misused in the media, and even in some scientific journals, and how statistics should be used correctly. A variety of search techniques will be utilized because the needed information pertains to disciplines other than mathematics. Even though the data come from such a variety of sources, such concepts as data summarization and presentation, probability distributions, and empirical estimations can be applied. Students will explore such sources as websites, government statistic databases, books, periodicals, and audio-visual materials.

Teaching Strategies: Students will search for needed information as part of problem solving assignments. Information sources will be suggested. Sources will be evaluated during classroom discussions and through written assignments.

Student Assignments: At the beginning of the semester, students will be provided articles from magazines, newspapers and the Internet. These articles will have considerable information on how the methods of statistics are used. The first assignment will require the students to search for examples of such articles. This assignment will lead to a student project that will require them to formulate a problem that is relevant to their intended area of specialization. The students will work out a relevant design of how the study will be conducted and will include obtaining a sample from which the data will be obtained.

Evaluations: The student project will be a semester-long activity. The students will be required to submit a report around the middle of the semester indicating the problem of interest, its relevance and how the project will be undertaken. In particular, they will describe the data collection process in detail. The instructor will give comments and suggestions on how the data collection will be done and to improve the final presentation of the project.

Objective No. 2: *Demonstrate capabilities for critical thinking, reasoning and analyzing.*

Emphasis: Significant

Content: This is one of the most significant emphases of Statistical Reasoning and is addressed by all components of the course. Critical thinking will be developed by considering various information sources from two points of view. First, students will be acquainted with techniques for detecting the misuse of statistics in published materials. For example, graphical presentations are frequently used to summarize data. However, many graphs in newspapers suffer from scale abuse. Second, after such misuses have been identified, Statistical Reasoning will address the issue and point out the correct methods for graphical data presentation. The constant focus of the course is for the students to understand the importance of scientific statistical data analysis methodology and decision-making.

Reasoning and analyzing skills will be practiced when the collected data sets are considered and problems in everyday statistics are recognized during class, on assignments, and on tests. This will require a high degree of critical analysis and reasoning by the students.

Teaching Strategies: In addition to the usual classroom lecture, the students will be introduced to a statistical software (e.g., SPSS or SAS) in order to undertake the basic analysis of the data gathered. The students will not be required to be proficient in the syntax but should develop a basic understanding on how the software will be used. One or two sessions will be needed in a computer laboratory or in a room that has access to a computer. Moreover, hands-on activities that will enable the students to discover concepts on their own will be implemented. This will be helpful to reinforce concepts that students typically find hard to comprehend.

Student Assignments: The second part of the student project described above will require the students to write a detailed discussion on the analysis of the gathered data with respect to the problem of interest. In addition, the students will be asked to critique the articles obtained at the beginning of the semester. Students will be expected to become very cognizant of the use and misuse of statistics.

Evaluations: Comments on the articles will be collected at two different times. This will be done to measure the statistical literacy of the students as the semester progresses.

Objective No. 3: *Demonstrate effective communication skills.*

Emphasis: Significant

Content: This is another objective given significant emphasis in Statistical Reasoning. The students will be introduced to basic statistical and mathematical notation that is essential to meaningful communication and proper solutions of problems. Identification of different types of graphs, charts, and tables is a major component of this course for achieving effective communication skills. The students are thus exposed to a variety of essential statistical concepts in classroom assignments and tests so that they in turn can use statistical data to communicate to their peers and the general public.

Teaching Strategies: First, students will observe statistics being communicated as the course material is presented in the classroom. As problems are solved, proper methods for presenting the results will be discussed. There will be an emphasis on correct usage of the statistical language. The instructor will point out ways in which statistics could be mis-communicated and discuss how such abuses can be avoided. On the other hand, daily assignments will require students to organize their solutions so that the information is accurately communicated. The instructor will be available for consultation outside the classroom to give further feedback and assistance. In order to give students experience in communicating statistics orally, they will present solutions to assigned problems to the class.

Student Assignments: As noted previously, the constant focus of the course is for the students to understand the importance of scientific statistical data analysis methodology and decision-making. Therefore, daily assignments will be given and the students will be practicing proper communication of statistical information and inferences that can be drawn from information that is given to them. The assignments will focus on 'why' and 'how' rather than on computing a specific answer, and the students will be required to provide answers that communicate effectively and accurately. In addition to the daily assignments, two detailed written reports on the student project will be collected. In the first half of the semester, students will be expected to discuss the nature and importance of the problem and to describe in detail the sampling scheme to be used. Students are not expected to have the data at this point. The written report will be returned to the students, graded and with suggestions on how to improve the presentation of the problem and how the data

collection should proceed. At the end of the semester, a final written report incorporating the instructor's written and oral comments and the final analysis of the data will be submitted. In addition, each student will be asked to give a short, oral presentation to the class.

Evaluations: Daily assignments will be graded on both accuracy of the answers and on effectiveness of how the answers are presented. Comments from the students regarding the oral presentation will be solicited. The instructor will evaluate the progress and quality of the project by grading the written reports and oral presentation.

Objective No. 4: *Demonstrate an understanding of human experiences and the ability to relate them to the present.*

Emphasis: Considerable

Content: Historical perspectives surface in both the content and the teaching strategies. Students will need to understand the historical significance of a set of data in order to properly interpret it. Also, understanding how statistics have been used (and misused) in the past is crucial to recognizing potential problems in the presentation of statistical data today. While this course will not study the techniques nor the developers of the techniques of modern statistics, it will look at how this relatively new field of science has changed as these techniques were brought forth. For example, a study of the United States census will give a better perspective on the current debates regarding census undercounts.

Teaching Strategies: The case can be made that statistics has been an important force in the molding of modern culture and a vital element of that culture. This course draws attention to that theme. When appropriate, references are made to convey the true spirit of statistics and the role statistics has played in the development of our civilization and in today's information age.

Student Assignments: Students will learn about important historical information that necessitated advances in statistics, and will study how human experiences have molded the way that society treats statistics today.

Evaluations: The assignments referred to above will be collected and evaluated.

Objective No. 5: *Develop an understanding of various cultures and their interrelationships.*

Emphasis: None

Objective No. 6: *Demonstrate the ability to integrate the breadth and diversity of knowledge and experience.*

Emphasis: Considerable

Content: In Statistical Reasoning, emphasis is placed upon the demonstration of this ability in content, assignments, and examinations through the incorporation of application problems into the various topics studied. Problems encountered in everyday life require the application of statistical principles. To be successful at analyzing such problems, students must be able to combine past experience and the diversity of knowledge to draw proper conclusions from given statistical data.

Teaching Strategies: It is well known that statistics applies to many areas. Topics will be presented that deal with the application of statistics to different fields of study. The instructor will demonstrate the importance of statistics today in many areas of human endeavor. Many problems will be considered, solved, and discussed in class.

Student Assignments: The articles obtained at the beginning of the semester will require the students to look at how statistics is used in everyday life. Moreover, the semester-long project will enable the students to apply what they have learned in the class to a field of study that has close proximity to their interest.

Evaluations: Collected assignments, tests, and projects will provide an evaluation of the students' abilities to integrate the breadth and diversity of their knowledge and experience.

Objective No. 7: *Demonstrate the ability to make informed, intelligent value decisions.*

Emphasis: Some

Content: The nature of statistics transcends any single human value system, any religion, any culture, or political system. The statistical techniques introduced in Statistical Reasoning give a more logical and scientific approach in applying these values.

Student Assignments: Students will be exposed to many different examples of statistical studies, both those that resulted in positive outcomes and those that resulted in negative outcomes. Learning about the traps and pitfalls of statistics will prepare the students to be able to identify when to use statistical data and when not to use it.

Evaluations: Selected reading assignments will be discussed and evaluated in class.

Objective No. 8: *Demonstrate the ability to make informed, sensitive aesthetic responses.*

Emphasis: Considerable

Content: Statistics is more than number crunching, a collection of facts to be committed to memory, or a series of technical skills to be mastered. David S. Moore, in his book *Statistics: Concepts and Controversies*, states "Statistical reasoning can produce data whose usefulness is not destroyed by variation and uncertainty." The beauty of properly approaching a set of data rests in the person's ability to analyze it properly, and to know when to use the results. Different graphical presentations of data are important in identifying the underlying distribution of the data. In content and method Statistical Reasoning students will be led to appreciate the beauty and patterns in graphs and charts.

Teaching Strategies: Evidence of statistical data presentations and patterns will be discussed. Students will have access to computer graphing software, graph their data in a variety of ways, and become acquainted with various graphical interpretations. The students will be encouraged, through studying many examples, to learn to identify which representation of the data is statistically correct and appealing.

Student Assignments: References to graph patterns, variable relationships, symmetry of data, and elegance and parsimony of statistical models will be included in daily assignments, lectures, and test problems.

Objective No. 9: *Demonstrate the ability to function responsibly in one's natural, social, and political environment.*

Emphasis: Considerable

Content: Statistics emphasizes critical thinking, which underlies man's ability to make decisions about research subjects based on the available data in a rational manner. Techniques of data summarization and analysis help the understanding of real data structure and make all data-based inferences more scientific. The

students can apply the methodologies introduced in Statistical Reasoning directly to interpreting statistical models of natural and social phenomena such as population growth, weather prediction, investment prediction, global economy monitoring, world hunger, disaster relief effort and government decision-making in domestic and foreign affairs. The rules of probability help students in understanding the industrial quality control process and product reliability assessment.

Teaching Strategies: Application problems related to the areas mentioned above will be presented, and students will discuss and analyze the results that statisticians derived.

Student Assignments: Articles will be given to the students to read and analyze that are relevant to present-day events. For instance, articles on polls and sample surveys will be discussed during an election year or when a relevant issue is of interest. In addition, problems in areas such as medical research (e.g., cancer research, medical breakthroughs) and psychological research (e.g., depression, child behavior) will be emphasized.

Evaluations: Written and/or oral comments will be solicited on the articles and problems assigned.

- IX. **Background:** Statistical ideas, statistical arguments, and the impact of statistical ideas on public policy and other areas of academic study form the basic structure of this course. These concepts are studied by examining data sets taken from government sources, current events, and research publications. Students use a statistical software package to analyze the data sets and then make written and oral presentations on their findings. Therefore, the instructor must be well-versed in statistics, be familiar with sources for data sets, and be able to advise students on writing and speaking skills.
- X. **Class Size:** The class size will be limited to 25 students to allow time for discussion of real world data sets, individual mentoring for the major project, and the in-class student presentations of the projects.