Statistical Reasoning 2.0

Course Outcomes

Dana Center Mathematics PATHWAYS

About *Statistical Reasoning*

Statistical Reasoning is designed for students who have completed *Foundations of Mathematical Reasoning* and the co-requisite *Frameworks for Mathematics and Collegiate Learning* course.

Course structure and contact hours

Statistical Reasoning is designed to be taught as a one-semester course with 4 student contact hours per week or in a quarter system with an equivalent number of contact hours. Some colleges may offer the course as a 3-credit course by removing topics.

Colleges may choose to offer *Statistical Reasoning* as a 4-credit course or as a combination of course credits and lab credits. Note that the curriculum is not designed for instruction in separate and distinct lab meetings. Rather, the intent is for the instructor to use all 4 contact hours for classroom instruction with embedded activities.

Active-learning design principles are evident in each lesson. Students will be expected to actively *do* statistics—analyzing data, constructing and testing hypotheses, solving problems, reflecting on their work, and making connections.

Statistical Reasoning is organized around broad statistical concepts. Statistical literacy and statistical thinking are primary themes. The course's nontraditional treatment of content will help students develop a conceptual understanding by supporting them in making connections between concepts and applying previously learned material to new contexts. It will prepare students for success in future courses, help them gain skills for the workplace, and help prepare them for participation as well-informed, productive citizens in our society.

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Structure of the curriculum

The curriculum is designed in 25-minute learning episodes, which may be paced to conform to any class length. These short bursts of active learning, combined with whole-class discussion and summary, can produce increased memory retention.[1]

[1] Sources: Buzan, T. (1989). *Master your memory* (Birmingham: Typesetters); Buzan, T. (1989). *Use your head* (London: BBC Books); Sousa, D. (2011). *How the brain learns*, 4th ed. (Thousand Oaks, CA: Corwin); Gazzaniga, M., Ivry, R. B., & Mangun, G. R. (2002). *Cognitive neuroscience: The biology of the mind*, 2nd ed. (New York: W. W. Norton); Stephane, M., Ince, N., Kuskowski, M., Leuthold, A., Tewfik, A., Nelson, K., McClannahan, K., Fletcher, C., & Tadipatri, V. (2010). Neural oscillations associated with the primary and recency effects of verbal working memory. *Neuroscience Letters*, *473*, 172–177; Thomas, E. (1972). The variation of memory with time for information appearing during a lecture. *Studies in Adult Education,* 57–62.

Readiness competencies

Students enrolling in *Statistical Reasoning* should be able to do the following:

- Demonstrate number sense, including dimensional analysis and conversions between fractions, decimals, and percentages. Determine when approximations are appropriate and when exact calculations are necessary.
- Solve linear equations, graph and interpret linear models, and read and apply formulas.
- Demonstrate a basic understanding of displays of univariate data—such as bar graphs, histograms, dotplots, and circle graphs, including appropriate labeling.
- Take charge of their own learning through good classroom habits, time management, and persistence. Participate in the class community through written and oral communication.

Learning goals

The following five learning goals apply to all DCMP mathematics courses, with the complexity and diversity of problem-solving skills and strategies increasing as students advance through the pathways.

For each course, we define the ways that the learning goals are applied and the expectations for mastery. The bullets below each of the five learning goals specify the ways in which each learning goal is addressed in the *Statistical Reasoning* course.

Each DCMP course is designed so that students meet the goals across the courses in a given pathway. Within a course, the learning goals are addressed across the course's content-based learning outcomes.

Communication Goal: You will be able to interpret and communicate quantitative information and mathematical and statistical concepts using language appropriate to the context and intended audience.

In the *Statistical Reasoning* course, you will...

- Use appropriate statistical language in oral, written, and graphical forms.
- Read and interpret graphs and descriptive statistics.
- Read short, authentic texts, such as graphical displays and journal and newspaper articles describing statistical studies. Evaluate the design, analysis, and conclusion of a given study both orally and in written form.

Problem-Solving Goal: You will be able to make sense of problems, develop strategies to find solutions, and persevere in solving them.

In the *Statistical Reasoning* course, you will...

- Understand what statistical question is being addressed, use appropriate strategies to answer the question of interest, and state conclusions using appropriate statistical language.

Reasoning Goal: You will be able to reason, model, and make decisions with mathematical, statistical, and quantitative information.

In the *Statistical Reasoning* course, you will...

- Use probability, graphical and numerical summaries of data, confidence intervals, and hypothesis testing methods to make decisions.
- Support conclusions by providing appropriate statistical justifications.
- Present short written or verbal justifications of decisions that include appropriate discussion of the mathematics involved.

Evaluation Goal: You will be able to critique and evaluate quantitative arguments that utilize mathematical, statistical, and quantitative information.

In the *Statistical Reasoning* course, you will...

- Identify errors—such as inappropriate sampling methods, sources of bias, and potentially confounding variables—in both observational and experimental studies.
- Identify mathematical or statistical errors, inconsistencies, or missing information in arguments.

Technology Goal: You will be able to use appropriate technology in a given context.

In the *Statistical Reasoning* course, you will...

- Use some form of spreadsheet application to organize information and make repeated calculations using simple formulas and statistical functions.
- Use the internet to find statistical information. Topics should be limited to those that can be researched with a simple search.
- Use internet-based tools appropriate for a given context (e.g., an online tool to calculate *p*-values).
- Use technology to calculate descriptive statistics and to test hypotheses.
- Interpret and apply output from a statistical software package.

Content learning outcomes

Statistical Reasoning is a first course in statistics and is intended for students in business, nursing, allied health, and the social and behavioral sciences, and for any student whose college and career paths require knowledge of the fundamentals of the collection, analysis, and interpretation of data.

Course topics include the presentation and interpretation of univariate data using graphical and numerical methods, probability, discrete and continuous probability distributions, linear regression, an understanding of good practice in study design, statistical inference, confidence intervals, and hypothesis testing. Emphasis is placed on the development of statistical thinking, the use of simulations, and the application of statistical software.

Students should develop an appreciation of the need for data to make good decisions and an understanding of the dangers inherent in basing decisions on anecdotal evidence rather than on data. To that end, students will use appropriate data-collection methods and statistical techniques to support reasonable conclusions through the following content learning outcomes:

- Data Exploration
- Statistical Design
- Probability and Simulation
- Statistical Inference

Data Exploration

Outcome: You will analyze data using graphical and numerical methods to study patterns and departures from patterns, using appropriate technology as needed.

You will be able to:

DE.1 Construct and interpret graphical displays of distributions of univariate data.

To include: Create and interpret dotplots, boxplots, stemplots, and histograms. Analyze center, shape, and spread, as well as clusters, gaps, outliers, and other unusual features.

DE.2 Summarize distributions of univariate data and compare multiple distributions.

To include: Compute measures of center (median, mean), measures of spread (range, interquartile range, standard deviation), and measures of position (quartiles, other percentiles, and standardized scores). Compare groups using back-to-back stemplots, parallel boxplots, and dotplots.

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DE.3 Explore bivariate data.

To include: Analyze scatterplots for patterns, linearity, outliers, and influential points. Determine the equation of the least-squares regression line and interpret its slope and intercept in context. Calculate and interpret the correlation coefficient and the coefficient of determination. Construct and interpret residual plots.

DE.4 Explore categorical data.

To include: Create and interpret frequency tables and bar charts, compare distributions of categorical data, use two-way tables to analyze and interpret marginal, joint, and conditional relative frequencies, and estimate the probability of events defined in context.

Statistical Design

Outcome: You will develop an appropriate data-collection plan to answer a given research question.

You will be able to:

SD.1 Identify characteristics of good study designs. Understand what conclusions are appropriate for a given design and whether conclusions can be generalized to a larger population.

To include: Identify the population of interest. Determine whether an observational or an experimental study is appropriate and feasible. Explain the difference between, and importance of, random selection and random assignment in study design.

SD.2 Plan and conduct an observational study when appropriate.

To include: Determine when a census or a sample survey is appropriate. Develop and implement an appropriate sampling plan (including the use of simple random, stratified, and cluster sampling). Identify potential sources of bias in sampling and surveys.

SD.3 Plan and conduct an experimental study when appropriate.

To include: Design and implement an appropriate plan for carrying out an experiment. Explain the purpose of including a control group and blinding in an experiment. Identify potential sources of confounding in an experiment.

Probability and Simulation

Outcome: You will use probability concepts and simulation.

You will be able to:

PS.1 Calculate and interpret probabilities.

To include: Interpret a probability as a long-run relative frequency of occurrence. Calculate the probability of a specified event in a chance experiment with equally likely outcomes. Determine probabilities using the complement rule, the addition rule for disjoint events, and the multiplication rule for independent events. Analyze and conduct simulations to estimate the probability of an event.

PS.2 Use probability distributions to describe the behavior of discrete and continuous random variables.

To include: Distinguish between discrete random variables and continuous random variables. Compute and interpret the mean and standard deviation of the probability distribution of a discrete random variable. Demonstrate an understanding of the mean, standard deviation, and shape of continuous probability distributions (uniform, normal, and skewed).

PS.3 Understand distributions.

To include: Distinguish between the distribution of a sample and a sampling distribution. Describe the sampling distributions of a sample mean and a sample proportion in terms of center, shape, and spread. Explain how these relate to sample size. Identify when the use of the normal distribution is appropriate. Use the normal distribution in modeling.

Statistical Inference

Outcome: You will use statistical models to draw conclusions from data.

You will be able to:

SI.1 Estimate population parameters using confidence intervals when appropriate.

To include: Verify that the appropriate conditions have been met. Construct one- and two-sample confidence intervals for means and for proportions. Interpret confidence intervals in context and interpret the confidence level associated with a confidence interval estimate. Analyze authentic statistical studies that report confidence intervals and evaluate whether the conclusions are reasonable.

SI.2 Conduct tests of significance when appropriate.

To include: Verify that the appropriate conditions have been met. Carry out one- and two- sample hypothesis tests for means and proportions, and for chi-squared tests. Identify appropriate hypotheses. Describe type I and type II errors in context. Interpret the meanings of rejection of the null hypothesis and of failure to reject the null hypothesis, in context. Demonstrate an understanding of the use of a *p*-value to reach a conclusion, and of the difference between practical significance and statistical significance. Analyze authentic statistical studies that report the results of a hypothesis test and evaluate whether the conclusions are reasonable.