Statistical Reasoning

Statistical Reasoning is a first course in statistics for students whose college and career paths require knowledge of the fundamentals of the collection, analysis and interpretation of data.

Topics include the presentation of interpretation of univariate and bivariate 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, simulation and the use of technology.

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 data. To that end, students will use appropriate data-collection methods and statistical techniques to support reasonable conclusion through the following student learning outcomes.

I. **Data Exploration**
   Students will analyze data using graphical and numerical methods to study patterns and departures from patterns, using appropriate technology as needed. Specifically, students will be able to:
   - **Construct and interpret graphical displays of distributions of univariate data.**
     o *Create and interpret dotplots, boxplots, stem and leaf plots and histograms.*
     o *Analyze center, shape and spread, as well as clusters, gaps, outliers and other unusual features.*
   - **Summarize distributions of univariate data and compare multiple distributions.**
     o *Compute measures of center (median, mean), measures of spread (range, interquartile range, standard deviation) and measures of position (quartiles, other percentiles and standardized scores).*
     o *Compare groups using back-to-back stem and leaf plots, parallel boxplots and dotplots.*
   - **Explore bivariate data.**
     o *Analyze scatterplots for patterns, linearity, and outliers.*
     o *Calculate and interpret the correlation coefficient.*
   - **Explore categorical data.**
     o *Create and interpret frequency tables and bar charts.*
     o *Compare distributions of categorical data.*

II. **Statistical Design**
   Students will critically evaluate a data-collection plan to answer a given research question. Specifically, students will be able to:
   - **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.**
     o *Identify the population of interest.*
     o *Determine whether an observational or experimental study is appropriate and feasible.*
     o *Explain the difference between and importance of random selection and random assignment in study design.*
   - **Know the elements of planning and conducting an observational study.**
     o *Verify basic elements of statistically valid sample survey.*
     o *Determine when a census or a sample survey is appropriate.*
     o *Identify potential sources of bias in sampling and surveys.*

- **Know the elements of planning and conducting an experimental study.**
  - o *Verify basic elements of statistically valid experimental design.*
  - o *Explain the purpose of including a control group and blinding in an experiment.*
  - o *Identify potential sources of confounding in an experiment.*

III. Probability and Simulation
Students will use probability concepts and simulation. Specifically, students will be able to:
- **Determine and interpret probabilities.**
  - o *Interpret a probability as a long-run relative frequency of occurrence.*
  - o *Calculate the probability of a specified event in a chance experiment with equally likely outcomes.*
- **Use probability distributions to describe the behavior of discrete and continuous random variables.**
  - o *Distinguish between discrete random variables and continuous random variables.*
  - o *Compute and interpret the mean and standard deviation of the probability distribution of a discrete random variable.*
  - o *Demonstrate an understanding of the mean, standard deviation and shape of continuous probability distributions (uniform, normal and skewed).*
- **Understand distributions.**
  - o *Distinguish between the distribution of a sample and a sampling distribution.*
  - o *Describe the sampling distributions of a sample mean and sample proportion in terms of center, shape and spread.*
  - o *Explain how these relate to sample size.*
  - o *Identify when the use of the normal distribution is appropriate.*

IV. Statistical Inference
Students will use statistical models to draw conclusions from data. Specifically, students will be able to:
- **Estimate population parameters including confidence intervals when appropriate.**
  - o *Verify that the appropriate conditions have been met.*
  - o *Construct one-sample confidence intervals for means and for proportions.*
  - o *Construct two-sample confidence intervals for means*
  - o *Interpret confidence intervals in context and explain the meaning of the confidence level associated with a confidence interval estimate.*
- **Conduct tests of significance when appropriate.**
  - o *Verify that the appropriate conditions have been met.*
  - o *Carry out one-sample hypothesis tests for means and proportions.*
  - o *Carry out two-sample hypothesis tests for means*
  - o *Interpret the meaning of rejection of the null hypothesis and of failure to reject the null hypothesis, in context.*
  - o *Demonstrate an understanding of the use of a p-value to reach a conclusion and of the difference between practical significance and statistical significance.*

V. Regression Modeling
  - o *Determine the equation of the least-squares regression line and interpret its slope and intercept in context.*