Carnegie Foundation
for the Advancement of Teaching

Statway® Pathway

INSTRUCTIONAL SYSTEM

- *Ambitious learning goals* leading to deep and long lasting understanding;
- *Lessons and out-of-class materials* to advance these goals;
- *Formative and summative assessments*, including end of module and end of course assessments;
- *Productive Persistence* - an evidence-based package of student activities and faculty actions developed from promising psychological research and expert practitioner knowledge integrated throughout the instructional system to increase student motivation, tenacity and skills for success;
- *Language and literacy* component which interweaves necessary supports in instructional materials and classroom activities so that learning is accessible to all;
- *Advancing Quality Teaching* component to provide instructors with the knowledge, skills, and habits necessary to experience efficacy in initial use and develop increasing expertise over time. This dimension is essential in seeking to reduce the variability in outcomes; and
- *Analytics to support the continuous improvement of teaching and of the materials.*

STATISTICS STUDENT LEARNING OUTCOMES FOR STATWAY

Consistent with the American Statistical Association's Guidelines for Assessment and Instruction in Statistics Education, the Statway learning outcomes center around providing students with a firm conceptual understanding that allows them to use statistical tools intelligently and to be sophisticated consumers of information from studies whose conclusions are based on data.

Students completing the Statway course will understand that data analysis is a process that begins with the formulation of a question that can be addressed with appropriate data, followed by the development of a thoughtful plan for identifying and collecting the necessary data. Students will know how data can be displayed and summarized in informative ways, and they will understand how the data can be used to draw conclusions in the presence of uncertainty.

CARNEGIE COMMITTEE FOR STATISTICS LEARNING OUTCOMES (CCSLO)

Rose Asera, The Carnegie Foundation for the Advancement of Teaching
Kris Bishop, Charles A. Dana Center at the University of Texas at Austin
Richelle (Rikki) Blair, American Mathematical Association of Two-Year Colleges (AMATYC); Lakeland Community College, OH
David Bressoud, Mathematical Association of America (MAA); Macalester College, MN
Bernadine Chuck Fong, The Carnegie Foundation for the Advancement of Teaching
John Climent, American Mathematical Association of Two-Year Colleges (AMATYC); Cecil College, MD
Peg Crider, Lone Star College, Tomball, TX

Jenna Cullinane, Charles A. Dana Center at the University of Texas at Austin

Bob del Mas, Consortium for the Advancement of Undergraduate Statistics Education (CAUSE); University of Minnesota

Karen Givvin, University of California, Los Angeles

Larry Gray, American Mathematical Society (AMS); University of Minnesota

Susan Hull, Charles A. Dana Center at the University of Texas at Austin

Rob Kimball, American Mathematical Association of Two-Year Colleges (AMATYC); Wake Technical Community College, NC

Dennis Pearl, Consortium for the Advancement of Undergraduate Statistics Education (CAUSE); The Ohio State University

Roxy Peck, American Statistical Association (ASA); Consortium for the Advancement of Undergraduate Statistics Education (CAUSE); California Polytechnic State University

Myra Snell, American Mathematical Association of Two-Year Colleges (AMATYC); Los Medanos College, CA

Jim Stigler, The Carnegie Foundation for the Advancement of Teaching; University of California, Los Angeles

Daniel Teague, Mathematical Association of America (MAA); North Carolina School of Science and Mathematics

Uri Treisman, The Carnegie Foundation for the Advancement of Teaching; Charles A. Dana Center at the University of Texas at Austin

The following learning outcomes have been chosen by the committee to enable students to achieve this overarching vision of what it means to be statistically literate.

STUDENT LEARNING OUTCOMES

S.1: Students will understand the data analysis process and the characteristics of well-designed statistical studies.

Learning Outcomes for S.1
Students should be able to:

- S.1.1 Develop a plan for a statistical study.
    a. Given a real-world problem, formulate a question that can be addressed by data.
    b. Identify appropriate data that can be used to address the question.
    c. Select an appropriate data collection strategy to address a question of interest.
- S.1.2 Know the type and scope of conclusions that can be drawn from different types of statistical studies (e.g., surveys, other observational studies, experiments).
- S.1.3 Know the characteristics of good sampling plans (e.g., representative of larger population, minimize sources of bias and variability), well-designed experiments (e.g., random assignment, replication, control, blocking), and well-designed observational studies (e.g., recognizing potential sources of bias).
- S.1.4 Critically evaluate all aspects of a study.

S.2: Students will demonstrate the use of distributional thinking to reason about the data in order to describe and summarize distributions of data, identify trends and patterns, judge the fit of a model to a distribution, and describe similarities and differences in comparing distributions. Distributional thinking involves the ability to consider a collection of individual observations as an entity (instead of focusing on individual observations) and to consider characteristics of the distribution to reason about the data.

Learning Outcomes for S.2
Students should be able to:

- S.2.1 Given a data set of a particular type (i.e., numerical, categorical, bivariate numerical, bivariate categorical, or time series).
    a. Display the data using appropriate graphical displays.
    b. Summarize the data using appropriate numerical summaries.
    c. Describe the data distribution in context.
    d. Viewing data as a model plus error, assess the appropriateness of potential models (e.g., normal distribution as a model for numerical data, the least squares regression line as a fit to bivariate numerical data, independence as a model for bivariate categorical data, linear or exponential growth as a model for time series data).
- S.2.2 Recognize different representations of the same data distribution (e.g., dotplot, boxplot, histogram) and understand how numerical summaries are related to characteristics of the data distribution (e.g., extreme left skew tends to have mean < median; the effect of outliers and influential observations).
- S.2.3 Make meaningful and appropriate comparisons of distributions of data collected from two or more different groups.

S.3: Students will demonstrate an ability to use appropriate statistical evidence to reason about population characteristics and about experimental treatment effects.

Learning Outcomes for S.3
Students should be able to:

- S.3.1 Demonstrate a basic understanding of probability.
    a. Interpret a probability.
    b. Estimate probabilities (including conditional probabilities) empirically and using simulation.
    c. Understand how a probability distribution models the behavior of a variable.
    d. Understand how sampling distributions model the behavior of a sample statistic (e.g., a sample mean or sample proportion).
- S.3.2 Understand how sampling distributions and probability support drawing conclusions based on data and assessing the associated risks.
- S.3.3 Understand the logic and reasoning used to interpret results from different types of statistical studies, including surveys, other observational studies, and experiments.
- S.3.4 Determine what statistical methods are appropriate in a given situation based on the goal of the analysis and the data available, and know and assess the conditions required for appropriate use of a given statistical method.
- S.3.5 Critically evaluate whether conclusions based on data are reasonable.
- S.3.6 Compute confidence interval estimates and interpret confidence intervals, confidence level, and margin of error in context.
- S.3.7 In a given context, determine appropriate null and alternative hypotheses and understand

what conclusions reasonably follow from a decision to reject the null hypothesis and from a decision not to reject the null hypothesis.

- S.3.8 Understand the concept of statistical significance, including significance levels and P-values.
- S.3.9 Carry out hypothesis tests to reach a conclusion and communicate the conclusion in context.

MATHEMATICS STUDENT LEARNING OUTCOMES

To best serve the diverse audience, the mathematics component of Statway focuses instruction and assessment on key concepts that support statistical thinking and data analysis.

Broad Objectives

- Students will be able to effectively use the language of mathematics to communicate ideas.
- Students will be proficient in procedural fluency, conceptual understanding, strategic competence, adaptive reasoning, and productive disposition.
- Students will be engaged in quantitative problems and investigations where they discover ideas and gain insights that develop questioning and solution-building skills.
- Students will use mental strategies and technology accurately and appropriately.

M.1. Numeracy: Students will develop and apply the concepts of numeracy to investigate and describe quantitative relationships and solve problems in a variety of contexts.

Learning Outcomes for M.1
Students will deepen their ability to reason and use numbers and be able to:

- M.1.1 Demonstrate number sense.
- M.1.2 Display proficiency in making calculations with rational numbers; know how and when to estimate results and round results.
- M.1.3 Create multiple representations of rational numbers and be able to recognize which representation is most useful for addressing a problem or to convey quantitative information.

M.2. Proportional Reasoning: Students will represent proportional relationships and solve problems that require an understanding of ratios, rates, proportions, and scaling.

Learning Outcomes for M.2
Students will be able to:

- M.2.1 Compare proportional relationships that may be represented in different ways and understand the role and function of **k** in the relationship **y** = **kx**.
- M.2.2 Distinguish between absolute difference and relative difference, and use percentages to describe changes in a quantity or the error of an estimate given the exact value of the quantity.
- M.2.3 Apply quantitative reasoning strategies to proportional relationships in realworld problems using units effectively and precisely.

M.3. Algebraic Reasoning: Students will reason using the language and structure of algebra to investigate, represent, and solve problems.

Learning Outcomes for M.3
Students will be able to:

- M.3.1 Use variables, evaluate expressions, and solve for unknown quantities and for quantities that may vary.
- M.3.2 Represent real-world and quantitative relationships with equations, inequalities, expressions, tables, verbal descriptions, symbols, and graphs.
- M.3.3 Solve equations and inequalities and explain how results relate to the original context.

M.4. Functions and Modeling: Students will understand functions as a way of modeling a correspondence between two variables. Students will be able to represent functions in various ways: verbally, algebraically, and graphically.

Statway focuses on linear and exponential functions.
Learning Outcomes for M.4
Students will be able to:

- M.4.1 Represent a function algebraically and be able to compute values of a function.
- M.4.2 Describe a function verbally, algebraically, graphically, and in a table of values, and make connections among representations.
- M.4.3 Make conjectures about the behavior of a function given several values of the function and a given context.
- M.4.4 Model situations with linear, quadratic, and exponential functions, inequalities and equations.
- M.4.5 Be able to investigate graphically and numerically (with technology) the effect of changing a parameter within a model.

For linear functions

- **M.4.6 Students will be able to:**
    a. Use linear functions to model situations involving constant rates of change.
    b. Describe the constant of proportionality, **slope**, as the rate of change of the function using appropriate units.
    c. Given the graph, an equation, or two or more points on a line, determine and interpret the intercept(s) and slope.
    d. Given a set of points that exhibit a linear trend, determine the line of best fit.
    e. Compute and interpret the errors or deviation from a line of best fit that is used to model a data set with a linear trend.

For exponential functions

- **M4.7 Students will be able to:**
    a. Identify and quantify exponential growth or decay in formulas, graphs, tables, and applications.
    b. Characterize and describe exponential models and compare them to other models.
    c. Use exponential functions to represent relationships between variables in involving exponential growth and decay.
    d. Describe transformations of the graphs of exponential functions.