Wall Township Public Schools	Board Approval Date: 8/19/2025

Course Title: Statistics CP

Course Description: Statistics is the science of understanding data. This course begins with an overview of statistical design, visual representations of data, and measures of central tendency and explores how these elements can be applied to everyday real-life situations. This course aims to introduce students to the critical thinking skills they need to understand statistical topics that they may encounter in the popular media or their future careers. Students will learn to critically evaluate the statistical information they encounter during everyday life, with a focus on becoming intelligent consumers, rather than producers, of data. Technology will be used to simplify calculation and display charts and graphs, and also to generate and access appropriate data for activities and projects. Graphing calculators are used extensively in this course.

New Jersey Student Learning Standards - Math

Vision for Mathematics Education in New Jersey

A New Jersey education in Mathematics builds quantitatively and analytically literate citizens prepared to meet the demands of college and career, and to engage productively in an information-driven society. All students will have access to a high-quality mathematics education that fosters a population that:

- leverages data in decision-making and as a lens for discussing, analyzing, and responding to practical questions.

- persists to make sense of and model problems arising in everyday life, society, and the workplace.
- thinks critically and strategically to assess quantitative relationships and to solutions to complex problems.
- employs precise reasoning and constructs viable arguments to deduce conclusions, recognize false statements and assess peers' reasoning.
- interprets, evaluates and critiques the mathematics embedded in social, scientific and commercial systems, as well as the claims made in the private and public sectors.
- communicates precisely when conveying, representing, and justifying both qualitative and quantitative perspectives.

Standards for Mathematical Practice*

The Standards for Mathematical Practice describe varieties of expertise that mathematics educators at all levels should seek to develop in their students. These practices rest on important "processes and proficiencies" with longstanding importance in mathematics education. The first of these are the NCTM process standards of problem solving, reasoning and proof, communication, representation, and connections. The second are the strands of mathematical proficiency specified in the National Research Council's report Adding It Up: adaptive reasoning, strategic competence, conceptual understanding (comprehension of mathematical concepts, operations and relations), procedural fluency (skill in carrying out procedures flexibly, accurately, efficiently and appropriately), and productive disposition (habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence and one's own efficacy).

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

**See end of document for additional information related to the mathematical practices.*

Inclusion of Climate Change Opportunities

( ) notes opportunities to integrate specific examples of climate change education provided by additional age-appropriate resources

The goal of inclusion of climate change education implementation is to foster generations of New Jersey students that can analyze, question, interpret, to think independently, and bring critical deduction to fulfill, and to lead in jobs created by burgeoning industries of the future green economy.

Course Sequence & Pacing

Unit Title	Estimated Number of Instructional Periods
Unit 1: Analyzing and Modeling One Variable Data	24
Unit 2: Analyzing Two Variable Data	14
Unit 3: Collecting Data	15
Unit 4: Probability and Random Variables	20
Unit 5: Sampling Distributions	10
Unit 6: Estimating a Parameter	10
Unit 7: Testing a Claim	10
Unit 8: Advanced Topics in Inference	24
Total Instructional Days:	127

Current instructional periods are 56 minutes and meet 3 times every 4 days.

Unit 1: Analyzing and Modeling One Variable Data

Desired Results

Unit 1: Analyzing and Modeling One Variable Data

Unit Summary: Unit 1 introduces students to data and the vocabulary of statistics. Students also learn to talk about data in real-world contexts. Variability in data may seem to suggest certain conclusions about the data distribution, but not all variation is meaningful. Statistics allows us to develop shared understandings of uncertainty and variation. In this unit, students will define and represent categorical and quantitative variables, describe and compare distributions of one-variable data, and interpret statistical calculations to assess claims about individual data points or samples. Students will also begin to apply the normal distribution model as an introduction to how theoretical models for populations can be used to describe some distributions of sample data. Later units will more fully develop probabilistic modeling and inference.

Learning Standards

NJSLS Math:

Interpreting Categorical and Quantitative Data S-ID

A. Summarize, represent, and interpret data on a single count or measurement variable

1. Represent data with plots on the real number line (dot plots, histograms, and box plots).

2. Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.

3. Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).

4. Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

B. Summarize, represent, and interpret data on two categorical and quantitative variables

5. Summarize categorical data for two categories in two-way frequency tables. Interpret relative frequencies in the context of the data (including joint, marginal, and conditional relative frequencies). Recognize possible associations and trends in the data.

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them
3. Construct viable arguments and critique the reasoning of others
4. Model with mathematics
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6. Attend to precision
7. Look for and make use of structure

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions

• 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

Computer Science & Design Thinking ***(****CS & DT****)*:

8.1.12.CS.4: Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors.

8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.

8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.

Learning Targets

Unit Essential Questions:

- Data can be organized and displayed in a variety of ways.
- Understanding the distribution of data is important to determine how to analyze the data.
- Describing the variation of data is as important as defining the center of a data set.

Unit Enduring Understandings:

- What method of displaying data would best represent my purpose?
- Why can technology support but not replace our mathematics skills and understanding?
- How can we compare data that is measured differently?

Vocabulary: individuals, variables, quantitative data, categorical data, frequency, relative frequency, symmetric, skewed, measure of center, measure of variability, mean, median, range, IQR, standard deviation, outlier, 1.5 x IQR Rule for outliers, z-score, percentile, segmented bar chart, association

Students will be able to:

- Identify the individuals and variables in a data set.
- Summarize the distribution of a variable with a frequency table or relative frequency table.
- Create and interpret bar charts of categorical data.
- Identify what makes some graphs of categorical data deceptive.
- Make and interpret dotplot, stemplots, and histograms of quantitative data.
- Compare distributions of quantitative data with dotplots, stemplots, and histograms.
- Find, compare, and interpret the mean and median of a distribution.
- Determine the better measure of center in a given setting.
- Find and interpret the range, IQR, and standard deviation of a distribution.
- Use the 1.5 x IQR rule to identify outliers.
- Create, interpret, and compare box plots of quantitative data.
- Find and interpret percentiles and z-scores in a distribution of quantitative data.
- Create a segmented bar chart to display the relationship between two categorical variables.

- Determine if an association exists between two categorical variables.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
  - *1 in 6 Wins: Students will use simulation to determine the probability of 2 winners in a group of 30*
  - *How many pairs of shoes do you own: Students will use real-life data and online applets to create a histogram to compare shoe ownership between populations.*
  - *How did Marty do on his quiz: Students will use data to calculate z-scores and percentiles and interpret them in context*
- see *Statistics and Probability with Applications* for suggested activities
  - Smelling Parkinson's
  - DID MR. STARNES STACK HIS CLASS?
  - MOTIVATING SHAPE, OUTLIERS, CENTER, VARIABILITY
  - SEEING TRIPLE
  - COMPARING GROUPS PROJECT AND RUBRIC
  - NORMAL DISTRIBUTIONS - CANDY AND PIRANHA
  - WHERE DO YOU STAND?
- *Climate Change Example: Students may represent geoscience data, with plots on the real number line, as they analyze results from global climate models.*

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Analyzing Categorical Data
  - Displaying and Comparing Quantitative Data
  - Summarizing Quantitative Data

○ Modeling Data Distributions
Summative Assessments: ● Students will explore an area of interest and collect data for a non-discrete quantitative variable (i.e. time it takes to get to school, arm span, amount of money in someone's pocket, GPA, etc). The data will be broken down into at least three subgroups of the population (i.e. freshman/sophomores/juniors/seniors, male/female/nonbinary, etc.). Students will calculate summary statistics and create parallel boxplots for the three data sets and create a display of the information to present to the class. Presentation must include comparing the distributions (shape, center, variability, and outliers) and justification for a reasonable conclusion about the data. ● Students will be given a data set and determine the values that are one, two, and three standard deviations from the mean using the z-score formula and find and interpret the 80th percentile, find and interpret the values with a z-score of -1.5 and +0.5.
Common Benchmark Assessments: ● Unit 1 Common Assessment ● Unit 1 Project (see above)
Alternative Assessments: ● Unit Assessments from Khan Academy

Core Instructional & Supplemental Materials
● Statistics and Probability with Applications- Fourth Edition
● Khan Academy: Statistics and Probability Course
● Stats Medic: 180 Days of Intro Stats

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:
Students receiving Special Education programming have specific goals and objectives, as well as accommodations and modifications outlined within their Individualized Education Plans (IEP) due to an identified disability and/or diagnosis. In addition to exposure to the general education curriculum, the instruction is differentiated based upon the student's needs. The IEP acts as a supplemental curriculum guide inclusive of instructional strategies that support each learner.

- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback
-Alternate or reduced work within Digital Platforms such as Khan Academy and Stats Medic

Specific Strategies and Practices that Support English Language Learners
English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

- Pre-teaching of vocabulary and concepts - Personal Glossary - Extended Time - Simplified/Verbal Instructions - Frequent Breaks - Visual learning, including graphic organizers - Use of cognates to increase comprehension - Teacher modeling - Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups
-Alternate or reduced work within Digital Platforms such as Khan Academy and Stats Medic

Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice
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504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students

It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

-Enrichment/Extension Activities within Digital Platforms such as Khan Academy and Stats Medic

Unit 2: Analyzing Two Variable Data

Desired Results

Unit 2: Analyzing Two Variable Data

Unit Summary: Building on Unit 1, students will explore relationships in two-variable categorical or quantitative data sets. They will use graphical and numerical methods to investigate an association between two categorical variables. Skills learned while working with two-way tables will transfer to calculating probabilities in Unit 4. Students will describe form, direction, strength, and unusual features for an association between two quantitative variables. They will assess correlation and, if appropriate, use a linear model to predict values of the response variable from values of the explanatory variable. Students will interpret the least-squares regression line in context, analyze prediction errors (residuals), and explore departures from a linear pattern.

Learning Standards

NJSLS Math:

Interpreting Categorical and Quantitative Data S-ID

B. Summarize, represent, and interpret data on two categorical and quantitative variables

6. Represent data on two quantitative variables on a scatter plot, and describe how the variables are related.

a. Fit a function to the data (including with the use of technology); use functions fitted to data to solve problems in the context of the data. Use given functions or choose a function suggested by the context. Emphasize linear and exponential models.

b. Informally assess the fit of a function by plotting and analyzing residuals, including with the use of technology.

c. Fit a linear function for a scatter plot that suggests a linear association.

C. Interpret linear models

7. Interpret the slope (rate of change) and the intercept (constant term) of a linear model in the context of the data.

8. Compute (using technology) and interpret the correlation coefficient of a linear fit.
9. Distinguish between correlation and causation.

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
7. Look for and make use of structure

Interdisciplinary Connections

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Learning Targets

Unit Essential Questions:	**Unit Enduring Understandings:**
• Correlation does not mean causation. • Outliers can influence the accuracy of predictions using a regression line.	• What can we learn from correlated bivariate data? • What effect do deviations from the trend have on predictions?

Vocabulary: explanatory, response, scatterplot, bivariate data, direction, form, strength, correlation, causation, extrapolation, residual, residual plot, least squares regression line, standard deviation of residuals, coefficient of determination

Students will be able to:

- Distinguish between explanatory and response variables for categorical data.
- Create a scatterplot to display the relationship between two quantitative variables.
- Describe the direction, form, and strength of a bivariate relationship and identify outliers.
- Estimate and interpret the correlation between two quantitative variables from a scatterplot.
- Distinguish correlation from causation.
- Make predictions using regression lines, keeping in mind the dangers of extrapolation.
- Calculate and interpret a residual.
- Interpret the slope and y-intercept of a regression line.
- Calculate the least-squares regression line using technology and using summary statistics.
- Describe how outliers affect the least-square regression line.
- Use a residual plot to determine whether a regression model is appropriate.
- Interpret the standard deviation of the residuals and r^2.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
  - *How many rubber bands does Barbie need for her bungee jump: Students will use the Barbie Bungee data to identify explanatory and response variables, scatterplots and how to describe a distribution.*

- *<u>How Good Are Predictions Using The Barbie Data?</u> : students will make predictions using regression lines and calculate and interpret a residual*
- *<u>Barbie Bunge Finale:</u> students will calculate a linear, quadratic and exponential model for the data*

- see *Statistics and Probability with Applications* for suggested activities
  - COMPARING DIFFERENT METHODS FOR DETERMINING A LINE OF BEST FIT
  - INTRODUCING THE QCR!
  - WALK IT OFF
- *Climate Change Examples:*
  - *Students may represent geoscience data on two quantitative variables on a scatter plot and describe how the variables are related in order to analyze the data and the results from global climate models.*
  - *Students may use linear or exponential functions fitted to geoscience data to solve problems and analyze the results from global climate models to make an evidence-based forecast of the current rate of global climate change.*

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Exploring Bivariate Numerical Data

Summative Assessments:

- Students will collect bivariate data (arm span vs. height, year vs. average temperature, number of rubber bands vs. Barbie drop length), create a scatterplot for the data, and describe the relationship between the variables. They will use technology to calculate the equation of the least-square regression line. They will also calculate the correlation, interpret the slope, and calculate and interpret the residual for an observation.

Common Benchmark Assessments:

- Unit 2 Common Assessment
- Unit 2 Project (see above)

Alternative Assessments:

- Unit Assessments from Khan Academy

Core Instructional & Supplemental Materials

- Statistics and Probability with Applications- Fourth Edition
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Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

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English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

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Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups
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Unit 3: Collecting Data

Desired Results

Unit 3: Collecting Data

Unit Summary: Depending on how data are collected, we may or may not be able to generalize findings or establish evidence of causal relationships. For example, if random selection is not used to obtain a sample from a population, bias may result and statistics from the sample cannot be assumed to generalize to the population. For data collected using well-designed experiments, statistically significant differences between or among experimental treatment groups are evidence that the treatments caused the effect. Students learn important principles of sampling and experimental design in this unit; they will learn about statistical inference in future units.

Learning Standards

NJSLS Math: Making Inferences and Justifying Conclusions S-IC

A. Understand and evaluate random processes underlying statistical experiments

1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

2. Decide if a specified model is consistent with results from a given data-generating process, e.g., using simulation. For example, a model says a spinning coin falls heads up with probability 0.5. Would a result of 5 tails in a row cause you to question the model?

B. Make inferences and justify conclusions from sample surveys, experiments, and observational studies

3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

6. Evaluate reports based on data.

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
4. Model with mathematics
6. Attend to precision
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Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

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Learning Targets

Unit Essential Questions:	**Unit Enduring Understandings:**

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- How can we describe data?
- To what extent can statistics help us make predictions and inferences about our world?
- How can we determine the validity of our interpretation of the statistics?

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- Data collection can be utilized to make summative statements or inferences about a population.
- Observational studies can be used to demonstrate correlation or association.
- Well-designed, controlled experiments can be used to make cause and effect conclusions.

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<tr>
<td colspan="2">Vocabulary: statistical study, observational study, experiment, convenience sampling, voluntary response sampling, bias, undercoverage, non response, simple random sample, sampling variability, simulation, confounding, treatments, subjects, random sampling, random assignment, control, replication, comparison, completely randomized design, statistical significance, population of interest</td>
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<td colspan="2">Students will be able to:

- Distinguish statistical questions from other types of questions.
- Identify the population and sample in a statistical study.
- Distinguish between an observational study and an experiment.
- Describe how convenience sampling and voluntary response sampling can lead to bias.
- Explain how random sampling can help to avoid bias.
- Explain how undercoverage, nonresponse, and other aspects of a sample survey can lead to bias.
- Describe how to obtain a simple random sample using slips of paper or technology.
- Explain the concept of sampling variability and the effect of increasing sample size.
- Use simulation to test a claim about a population proportion.
- Explain the concept of confounding and how it limits the ability to make cause-and-effect conclusions.
- Identify the treatments in an experiment.
- Explain the purpose of a control group in an experiment.
- Describe how to randomly assign treatments in an experiment using slips of paper or technology.
- Explain the purpose of random assignment in an experiment.

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- Identify other sources of variability in an experiment and explain the benefits of keeping these variables the same for all experimental units.
- Outline an experiment that uses a completely randomized design.
- Explain the concept of statistical significance in the context of an experiment.
- Use simulation to determine if the difference between two means or two proportions in an experiment is statistically significant.
- Identify the population to which inferences from a sample can be made.
- Determine when it is appropriate to make an inference about cause and effect.
- Evaluate if a statistical study has been carried out in an ethical manner.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
    - *Is anchored putting better: Students will learn about anchor putting and how it was banned and then collect data using appropriate methods to eventually determine its effectiveness.*
    - *How much TV do students watch: Students will use prepared data to estimate a margin of error.*
    - *Does listening to music improve GPA: Students will evaluate different methods to complete a statistical study and determine what they can infer to a population of interest based on the design.*
- see *Statistics and Probability with Applications* for suggested activities
    - GEOGRAPHY QUIZ
    - SHOW ME THE MONEY
    - RESPONSE BIAS PROJECT

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Study Design

Summative Assessments:

- Students will design and execute an observational study to explore the differences in responses when individuals are asked a biased and unbiased question. Students will create a product to display the collected data, describe how they collected data and how that data collection methodology affected their data.
- Students will design and execute an experiment to test a hypothesis of their choice. Students should be sure to include the common experimental design vocabulary, utilize the four principles of experimental design and describe the importance of each as it relates to their experiment.
- Students will find a recent headline based on the results of a study and analyze the original study to determine limitations within the design and compare the media's report to the implications in the actual study.

Common Benchmark Assessments:

- Unit 3 Common Assessment
- Unit 3 Project (see above)

Alternative Assessments:

- Unit Assessments from Khan Academy

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Unit 4: Probability and Random Variables

Desired Results

Unit 4: Probability and Random Variables

Unit Summary: Probabilistic reasoning allows statisticians to quantify the likelihood of random events over the long run and to make statistical inferences. Simulations and concrete examples can help students to understand the abstract definitions and calculations of probability. This unit builds on understandings of simulated or empirical data distributions and fundamental principles of probability to represent, interpret, and calculate parameters for theoretical probability distributions for discrete random variables. Interpretations of probabilities and parameters associated with a probability distribution should use appropriate units and relate to the context of the situation.

Learning Standards

NJSLS Math:

Conditional Probability and the Rules of Probability S-CP

A. Understand independence and conditional probability and use them to interpret data

1. Describe events as subsets of a sample space (the set of outcomes) using characteristics (or categories) of the outcomes, or as unions, intersections, or complements of other events ("or," "and," "not").
2. Understand that two events A and B are independent if the probability of A and B occurring together is the product of their probabilities, and use this characterization to determine if they are independent.
3. Understand the conditional probability of A given B as P(A and B)/P(B), and interpret independence of A and B as saying that the conditional probability of A given B is the same as the probability of A, and the conditional probability of B given A is the same as the probability of B.
4. Construct and interpret two-way frequency tables of data when two categories are associated with each object being classified. Use the two-way table as a sample space to decide if events are independent and to approximate conditional probabilities. For example, collect data from a random sample of students in your school on their favorite subject among math, science, and English. Estimate the probability that a randomly selected student

from your school will favor science given that the student is in tenth grade. Do the same for other subjects and compare the results.

5. Recognize and explain the concepts of conditional probability and independence in everyday language and everyday situations. For example, compare the chance of having lung cancer if you are a smoker with the chance of being a smoker if you have lung cancer.

B. Use the rules of probability to compute probabilities of compound events in a uniform probability model

6. Find the conditional probability of A given B as the fraction of B's outcomes that also belong to A, and interpret the answer in terms of the model.

7. Apply the Addition Rule, P(A or B) = P(A) + P(B) – P(A and B), and interpret the answer in terms of the model.

8. (+) Apply the general Multiplication Rule in a uniform probability model, P(A and B) = P(A)P(B|A) = P(B)P(A|B), and interpret the answer in terms of the model.

9. (+) Use permutations and combinations to compute probabilities of compound events and solve problems.

Using Probability to Make Decisions S-MD

A. Calculate expected values and use them to solve problems

1. (+) Define a random variable for a quantity of interest by assigning a numerical value to each event in a sample space; graph the corresponding probability distribution using the same graphical displays as for data distributions.

2. (+) Calculate the expected value of a random variable; interpret it as the mean of the probability distribution.

3. (+) Develop a probability distribution for a random variable defined for a sample space in which theoretical probabilities can be calculated; find the expected value. For example, find the theoretical probability distribution for the number of correct answers obtained by guessing on all five questions of a multiple-choice test where each question has four choices, and find the expected grade under various grading schemes.

4. (+) Develop a probability distribution for a random variable defined for a sample space in which probabilities are assigned empirically; find the expected value. For example, find a current data distribution on the number of TV sets per household in the United States, and calculate the expected number of sets per household. How many TV sets would you expect to find in 100 randomly selected households?

B. Use probability to evaluate outcomes of decisions

5. (+) Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected

values.

a. Find the expected payoff for a game of chance. For example, find the expected winnings from a state lottery ticket or a game at a fast food restaurant.

b. Evaluate and compare strategies on the basis of expected values. For example, compare a high-deductible versus a low-deductible automobile insurance policy using various, but reasonable, chances of having a minor or a major accident.

6. (+) Use probabilities to make fair decisions (e.g., drawing by lots, using a random number generator).

7. (+) Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).

Standards for Mathematical Practice

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

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions

9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

Computer Science & Design Thinking (*CS & DT***):**

8.1.12.CS.4: Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors.
8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.
8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.

Learning Targets

Unit Essential Questions:

- Probability is the approximate proportion of outcomes that we would expect to occur over a large number of trials.
- The basic rules of probability and using area under approximately normal distributions can be used to calculate most probabilities.
- Given certain conditions are met, sampling distributions can be used to estimate the likelihood of a sample's summary statistics occuring in a population.

Unit Enduring Understandings:

- What is probability?
- How do we use normal distributions and other techniques to calculate probability in a variety of situations?
- How do we calculate the likelihood of getting a specific sample in a population?

Vocabulary: relative frequency, simulation, probability model, complement rule, addition rule, mutually exclusive, probability, two way table, venn diagram, conditional probability, independent events, tree diagrams, general multiplication rule, multiplication, counting principle, factorial, permutation, combination, random variable, discrete, continuous, binomial random variable, binompdf, binomcdf

Students will be able to:

- Interpret probability as a long-run relative frequency.
- Avoid common myths about randomness.
- Use simulation to model chance behavior.
- Give a probability model for a chance process with equally likely outcomes and use it to find the probability of an event.
- Use the complement rule to find probabilities.
- Use the addition rule for mutually exclusive events to find probabilities.
- Use a two-way table to find probabilities.
- Calculate probabilities with the general addition rule.
- Use a Venn diagram to find probabilities.
- Find and interpret conditional probabilities using two-way tables.
- Use the conditional probability formula to calculate probabilities.
- Determine whether two events are independent.
- Use the general multiplication rule to calculate probabilities.
- Use a tree diagram to model a chance process involving a sequence of outcomes.
- Calculate conditional probabilities using tree diagrams.
- Use the multiplication rule for independent events to calculate probabilities.
- Calculate P(at least one) using the complement rule and the multiplication rule for independent events.
- Determine if it is appropriate to use the multiplication rule for independent events in a given setting.
- Use the multiplication counting principle to determine the number of ways to complete a process involving several steps.
- Use factorials to count the number of permutations of a group of individuals.
- Compute the number of permutations of n individuals taken r at a time.
- Use combinations to calculate probabilities.
- Use the multiplication counting principle and combinations to calculate probabilities.
- Calculate probabilities involving a discrete random variable.

- Classify a random variable as discrete or continuous.
- Calculate probabilities involving a continuous random variable.
- Make a histogram to display the probability distribution of a discrete random variable and describe its shape.
- Calculate and interpret the mean (expected value) of a discrete random variable.
- Calculate and interpret the standard deviation of a discrete random variable.
- Determine whether the conditions for a binomial setting are met.
- Calculate probabilities involving a single value of a binomial random variable.
- Make a histogram to display a binomial distribution and describe its shape.
- Use a formula to find probabilities involving several values of a binomial random variable.
- Use technology to find probabilities involving several values of a binomial random variable.
- Calculate and interpret the mean and standard deviation of a binomial random variable.
- Determine if it is appropriate to use normal approximation to a binomial distribution.
- When appropriate, use normal approximation to a binomial distribution to calculate probabilities.
- Determine if it is appropriate to use normal approximation to a binomial distribution.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
  - *What is the probability of being a male with blue eyes:Students will give a probability model for a chance process and use it to find the probability of an event.*
  - *Can we predict traffic jams and snow days: Students will use the multiplication rule for independent events to calculate probabilities.*
  - *How many ways can you order a hamburger: Students will compute the number of combinations and use combinations to calculate probabilities.*
- see *Statistics and Probability with Applications* for suggested activities
  - PROMOTION DISCRIMINATION
  - THE LAST BANANA
  - WHAT'S IN A STRADIVARIUS

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Probability
  - Counting, permutations, and combinations
  - Random Variables
  - Sampling Distributions

Summative Assessments:

- Students will research the game of blackjack with one deck of cards and play a hand on camera. They will then provide a narrative and describe the calculations for the probabilities involved for each card drawn.
- Project 12 TASTE THE DIFFERENCE: To model a taste test to the binomial distribution and perform an informal hypothesis test for proportions. The student is to gather data and use the binomial probability density function and model the binomial distribution with the standard normal distribution. The TI-83 calculator (or equal), the binomialpdf, and binomialcdf functions will be used.

Common Benchmark Assessments:

- Unit 4 Common Assessment
- Unit 4 Project (see above)

Alternative Assessments:

- Unit Assessments from Khan Academy

Core Instructional & Supplemental Materials

- Statistics and Probability with Applications- Fourth Edition
- Khan Academy: Statistics and Probability Course
- Stats Medic: 180 Days of Intro Stats

Accommodations and Modifications:
Students with Disabilities, English Language Learners,
Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:

Students receiving Special Education programming have specific goals and objectives, as well as accommodations and modifications outlined within their Individualized Education Plans (IEP) due to an identified disability and/or diagnosis. In addition to exposure to the general education curriculum, the instruction is differentiated based upon the student's needs. The IEP acts as a supplemental curriculum guide inclusive of instructional strategies that support each learner.

- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback
-Alternate or reduced work within Digital Platforms such as Khan Academy and Stats Medic

Specific Strategies and Practices that Support English Language Learners

English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

- Pre-teaching of vocabulary and concepts - Personal Glossary - Extended Time - Simplified/Verbal Instructions - Frequent Breaks - Visual learning, including graphic organizers - Use of cognates to increase comprehension - Teacher modeling - Pairing students with beginning English language skills with students who have more advanced English language skills - Scaffolding - Word walls - Think-pair-share - Cooperative learning groups
-Alternate or reduced work within Digital Platforms such as Khan Academy and Stats Medic

Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice
-Alternate or reduced work within Digital Platforms such as Khan Academy and Stats Medic

Students with 504 Plans

Teachers are responsible for implementing designated services and strategies identified on a student’s 504 Plan.

504 plans are formal plans that schools develop to give kids the support they need and covers any condition that limits daily activities in a major way. Students' accommodations are outlined in their individual 504 plan.

Specific Strategies and Practices that Support Gifted & Talented Students

It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

-Homogenous Grouping - Small Group In-Depth Instruction - Differentiated Online Practice - Alternative Assessments - Pre-Assess to provide Differentiated Instruction to Accelerate Learning

-Enrichment/Extension Activities within Digital Platforms such as Khan Academy and Stats Medic

Unit 5: Sampling Distributions

Desired Results

Unit 5: Sampling Distributions

Unit Summary: This unit applies probabilistic reasoning to sampling, introducing students to sampling distributions of statistics they will use when performing inference in future units. Students should understand that sample statistics can be used to estimate corresponding population parameters and that measures of center (mean) and variability (standard deviation) for these sampling distributions can be determined directly from the population parameters when certain sampling criteria are met. For large enough samples from any population, these sampling distributions can be approximated by a normal distribution. Simulating sampling distributions helps students to understand how the values of statistics vary in repeated random sampling from populations with known parameters.

Learning Standards

NJSLS Math: Making Inferences and Justifying Conclusions S-IC

A. Understand and evaluate random processes underlying statistical experiments

1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

B. Make inferences and justify conclusions from sample surveys, experiments, and observational studies

3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

6. Evaluate reports based on data.

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them
2. Reason abstractly and quantitatively
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision
8. Look for and express regularity in repeated reasoning

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions

• 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

Computer Science & Design Thinking (*CS & DT***):**

8.1.12.CS.4: Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors.

8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.

8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.

Learning Targets

Unit Essential Questions:	**Unit Enduring Understandings:**
• How likely is it to get a value this large just by chance? • How can we anticipate patterns in the values of a statistic from one sample to another?	• The p-value of a statistic can be found by estimation of shape, center, and spread for a sampling distribution. • Sampling variability is typical in sampling using randomization.

Vocabulary: parameter, statistic, sampling distribution, unbiased estimator, variability

Students will be able to:

- Distinguish between a parameter and a statistic.
- Create a sampling distribution using all possible samples from a small population.
- Use the sampling distribution of a statistic to evaluate a claim about a parameter.
- Determine if a statistic is an unbiased estimator of a population parameter.
- Describe the relationship between sample size and the variability of a statistic.
- Calculate the mean and standard deviation of the sampling distribution of a sample proportion and interpret the standard deviation.
- Determine if the sampling distribution of p-hat is approximately normal.
- Use a normal distribution to calculate probabilities involving p-hat.
- Find the mean and standard deviation of the sampling distribution of a sample mean x-bar and interpret the standard deviation.
- Use a normal distribution to calculate probabilities involving x-bar when sampling from a normal population.
- Determine if the sampling distribution of x-bar is approximately normal when sampling from a non-normal population.
- Use a normal distribution to calculate probabilities involving x-bar.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*

- *Guess the midterm average: Student will be given prepared data and using sampling to estimate the average score on the midterm exam*
- *Is this a fair coin: Students will use the sampling distribution of sample means to determine whether a coin is fair or not*
- *Who has better ACT scores: Using an applet and prepared data, students will determine the shape of a sampling distribution of sample means given various skewed or symmetric population data.*

- see *Statistics and Probability with Applications* for suggested activities
  - Sampling Movies
  - OVERVIEW FOR TEACHERS

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Sampling Distributions

Summative Assessments:

- Project 9 THE AGE OF A PENNY: To determine the approximate age of pennies in circulation. The distribution of the ages, not the year the coin was minted, will be examined. The central limit theorem will be used to form an interval estimation of the ages for your sample of coins.
- Students will create a sampling distribution for a proportion and another for a mean using student-collected data. They will compare the center, shape, and spread and use the information to make a conjecture about the population of interest.

Common Benchmark Assessments:

- Unit 5 Common Assessment
- Unit 5 Project (see above)

Alternative Assessments:

- Unit Assessments from Khan Academy

Core Instructional & Supplemental Materials

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- Khan Academy: Statistics and Probability Course
- Stats Medic: 180 Days of Intro Stats

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

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Students at Risk of Failure

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-Enrichment/Extension Activities within Digital Platforms such as Khan Academy and Stats Medic

Unit 6: Estimating a Parameter

Desired Results

Unit 6: Estimating a Parameter

Unit Summary: This unit introduces statistical inference, which will continue through the end of the course. Students will analyze data to make inferences about single population parameters. Provided conditions are met, students will use statistical inference to construct and interpret confidence intervals to estimate parameters. Students should understand that z distributions are used for proportions and t distributions are used for inference with means when the population standard deviation is not known.

Learning Standards

NJSLS Math: Making Inferences and Justifying Conclusions S-IC

A. Understand and evaluate random processes underlying statistical experiments

1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

B. Make inferences and justify conclusions from sample surveys, experiments, and observational studies

3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

6. Evaluate reports based on data.

Standards for Mathematical Practice

1. Make sense of problems and persevere in solving them

2. Reason abstractly and quantitatively
4. Model with mathematics
5. Use appropriate tools strategically
6. Attend to precision

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions

• 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

Computer Science & Design Thinking *(CS & DT)*:

8.1.12.CS.4: Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors.

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8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.

Learning Targets

Unit Essential Questions:	**Unit Enduring Understandings:**
• What does a confidence interval tell us?	

• What other statistical ideas are the foundations behind the logic of hypothesis tests?	• A confidence interval gives a range of plausible values for a population parameter based on a sample. • Probability, random variables, sampling distributions, and sampling variability are the foundational concepts that all inferential procedures are built on.
Vocabulary: confidence interval, point estimate, margin of error, confidence level, critical value, random condition, large counts condition, 10% rule, four step process, z-interval, t-interval	
Students will be able to: • Interpret a confidence interval. • Determine the point estimate and margin of error from a confidence interval. • Use confidence intervals to make decisions. • Describe how the confidence level and sample size affect the margin of error. • Explain how practical issues like nonresponse, undercoverage, and response bias can affect the interpretation of a confidence interval. • Check the Random and Large Counts conditions for constructing a confidence interval for a population proportion. • Determine the critical value for calculating a C% confidence interval for a population proportion using Table A or technology. • Calculate a C% confidence interval for a population proportion. • Use the four-step process to construct and interpret a confidence interval for a population proportion. • Determine the sample size required to obtain a C% confidence interval for a population proportion with a specified margin of error. • State and check the Random and Normal/Large Sample conditions for constructing a confidence interval for a population mean.	

- Determine critical values for calculating a C% confidence interval for a population mean.
- Calculate a C% confidence interval for a population mean.
- Use sample data to check the Normal/Large Sample condition.
- Use the four-step process to construct and interpret a confidence interval for a population mean.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
  - *Guess the Mystery Mean: Students will interpret a confidence interval in context and margin of error from a confidence interval.*
  - *How much of the Earth is covered by water: Students will determine the sample size required to obtain a C% confidence interval for a population proportion with a specified margin of error.*
  - *How many states can you name: Students will use the four-step process to construct and interpret a confidence interval for a population mean.*
- see *Statistics and Probability with Applications* for suggested activities
  - SNICKERS FUN SIZE MASSES
  - SAMPLING FROM A NORMAL POPULATION
  - FLIPPING KISSES

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Confidence Intervals

Summative Assessments:

- Students will create a question about a topic of interest, collect the appropriate data and perform the four step process to use the data to answer the question. (This assessment could be completed multiple times using both categorical and quantitative data.) Students will create a display of their procedure and findings, similar to the project described here.

Common Benchmark Assessments:

- Unit 6 Common Assessment
- Unit 6 Project (see above)

Alternative Assessments:

- Unit Assessments from Khan Academy

Core Instructional & Supplemental Materials

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Students at Risk of Failure

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Unit 7: Testing a Claim

Desired Results

Unit 7: Testing a Claim

Unit Summary: Students will perform significance tests to evaluate claims about parameters. They will also interpret the two types of errors that can be made in a significance test, their probabilities, and possible consequences in context. Using s for in the formula for z gives a slightly different value, t, whose distribution, which depends on sample size, has more area in the tails than a normal distribution. The boundaries for rejecting a null hypothesis using a t-distribution tend to be further from the mean than for a normal distribution. Students should understand how and why conditions for inference with proportions and means are similar and different.

Learning Standards

NJSLS Math: Making Inferences and Justifying Conclusions S-IC

A. Understand and evaluate random processes underlying statistical experiments

1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

B. Make inferences and justify conclusions from sample surveys, experiments, and observational studies

3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

6. Evaluate reports based on data.

Standards for Mathematical Practice

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

Interdisciplinary Connections

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• 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

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8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.

Learning Targets

Unit Essential Questions:	**Unit Enduring Understandings:**

• What does it mean to obtain statistically significant results? • How do we know whether to use a t-test or a z-test for inference? • Why is it inappropriate to accept a hypothesis as true based on the results of statistical inference testing?	• Statistically significance results mean that the sample data is unlikely to occur by chance alone, assuming the null hypotheses is true. • In inferential procedures, a t-test is used when the population standard deviation is unknown • The null hypothesis is assumed to be true at the beginning of an inferential procedure.
Vocabulary: null hypotheses, alternate hypotheses, p-value, significance test, Type 1 Error, Type II Error, standardized test statistic, one sided significance test, two sided significance test, z-test, t-test	
Students will be able to: • State appropriate hypotheses for a significance test about a population parameter. • Interpret a p-value in context. • Make an appropriate conclusion for a significance test based on a P-value. • Interpret a Type I error and a Type II error in context. • Give a consequence of a Type I error and a Type II error in a given setting. • Check the Random and Large Counts conditions for performing a significance test about a population proportion. • Calculate the standardized test statistic for a significance test about a population proportion • Find the P-value for a one-sided significance test about a population proportion using Table A or technology. • Use the four-step process to perform a one-sided significance test about a population proportion. • Calculate the P-value for a two-sided significance test about a population proportion using Table A or technology. • Use the four-step process to perform a two-sided significance test about a population proportion. • Check the Random and Normal/Large Sample conditions for performing a significance test about a population mean. • Calculate the standardized test statistic for a significance test about a population mean.	

- Find the P-value for a significance test about a population mean using Table B or technology.
- Use the four-step process to perform a significance test about a population mean.
- Use a confidence interval to make a conclusion about a two-sided test for a population mean.
- Understand how to wisely use and interpret the results of significance tests.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
  - *Is Mrs. Gallas a good free throw shooter: Students will use a sample proportion to create a sampling distribution to determine and interpret a p-value.*
  - *Can you taste the rainbow: Students will collect data using Skittles and perform a hypothesis test to determine whether Skittles have different flavors*
  - *Should Flint switch to bottled water: Using real-world data, students will perform a hypothesis test to determine the safety of the water in Flint, MI. Students will also describe a Type I and Type II error in context and describe the consequences of each error.*
- see *Statistics and Probability with Applications* for suggested activities
  - A-Massing More Snickers
  - Flipping More Kisses
  - Sampling From a Normal Population

Unit 7 Stage 2 Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Significance Tests

Summative Assessments:

- Students will create a question about a topic of interest, collect the appropriate data and perform the four step process to use the data to answer the question. (This assessment could be completed multiple times using both

categorical and quantitative data.) Students will create a display of their procedure and findings, similar to the project described here.

Common Benchmark Assessments:

- Unit 7 Common Assessment
- Unit 7 Project (see above)

Alternative Assessments:

- Unit Assessments from Khan Academy

Core Instructional & Supplemental Materials

- Statistics and Probability with Applications- Fourth Edition
- Khan Academy: Statistics and Probability Course
- Stats Medic: 180 Days of Intro Stats

Accommodations and Modifications: Students with Disabilities, English Language Learners, Students at Risk of Failure, Students with 504s, Gifted & Talented Students

Specific Strategies and Practices that Support Students with Disabilities:

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- Small group/One to one - Additional time - Review of directions - Student restates information - Space for movement or breaks - Extra visual and verbal cues and prompts - Preferential seating - Follow a routine/schedule - Rest breaks - Verbal and visual cues regarding directions and staying on task - Checklists - Immediate feedback

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English language learner (ELL) is a national-origin-minority student who is limited-English-proficient. This term is often preferred over limited-English-proficient (LEP) as it highlights accomplishments rather than deficits.

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Students at Risk of Failure

- Home/School Connection - Alternative Assessments - Learning Contracts - Homogenous Grouping - Supplemental Instruction - Think-Pair-Share by Readiness - Homework Options - Differentiated Online Practice - Leveled Rubrics - Tiered Level of Supports - Tiered Activities - Small Group Instruction - Work Alone Choice - Group Work Choice
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It is critical that all teachers are able to recognize a high-ability student who may need more depth and complexity in instruction.

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Unit 8: Advanced Topics in Inference

Desired Results

Unit 8: Advanced Topics in Inference

Unit Summary: This unit introduces two sample tests for proportions and means, as well as chi-square tests, which can be used when there are two or more categories. Students need to understand how to select from the following tests: the chi-square test for goodness of fit (for a distribution of proportions of one categorical variable in a population), the chi-square test for independence (for associations between categorical variables within a single population), or the chi-square test for homogeneity (for comparing distributions of a categorical variable across populations or treatments). To integrate conceptual understanding, teachers can make connections between frequency tables, conditional probability, and calculating expected counts. The chi-square statistic is introduced to measure the distance between observed and expected counts relative to expected counts.

Learning Standards

NJSLS Math: Making Inferences and Justifying Conclusions S-IC

A. Understand and evaluate random processes underlying statistical experiments

1. Understand statistics as a process for making inferences about population parameters based on a random sample from that population.

B. Make inferences and justify conclusions from sample surveys, experiments, and observational studies

3. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

4. Use data from a sample survey to estimate a population mean or proportion; develop a margin of error through the use of simulation models for random sampling.

5. Use data from a randomized experiment to compare two treatments; use simulations to decide if differences between parameters are significant.

6. Evaluate reports based on data.

Standards for Mathematical Practice

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

Interdisciplinary Connections

Career Readiness, Life Literacies, & Key Skills *(CLKS)*:

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

9.4.12.CT.2: Explain the potential benefits of collaborating to enhance critical thinking and problem solving

9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions

• 9.4.12.TL.3: Analyze the effectiveness of the process and quality of collaborative environments.

Computer Science & Design Thinking *(CS & DT)*:

8.1.12.CS.4: Develop guidelines that convey systematic troubleshooting strategies that others can use to identify and fix errors.

8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.

8.1.12.DA.5: Create data visualizations from large data sets to summarize, communicate, and support different interpretations of real-world phenomena.

8.2.12.NT.1: Explain how different groups can contribute to the overall design of a product.

Learning Targets

Unit Essential Questions:

- How does increasing the degrees of freedom influence the shape of the t- distribution and chi-square distribution?
- Why is it inappropriate to use statistical inference to justify a claim that there is no association between variables?

Unit Enduring Understandings:

- Increasing the degrees of freedom increases the area on the tails of the distribution, which could change the likelihood of statistically significant results.
- Inferential techniques provide (or do not provide) convincing, not definitive, evidence in favor of the alternative hypotheses. The null hypothesis is assumed to be true at the beginning of an inferential procedure.

Vocabulary: difference of means, mean difference, paired data, chi-square goodness of fit, chi-square test for homogeneity, chi-square test for independence, chi-square distribution, observed count, expected count, expected count condition, t-test and t-interval for slope

Students will be able to:

- Check the Random and Large Counts conditions for constructing a confidence interval for a difference between two proportions.
- Calculate a C% confidence interval for a difference between two proportions.
- Use the four-step process to construct and interpret a confidence interval for the difference between two proportions.
- State hypotheses and check conditions for performing a significance test about a difference between two proportions.
- Calculate the standardized test statistic and P-value for a significance test about a difference between two proportions.
- Use the four-step process to perform a significance test about a difference between two proportions.

- Check the Random and Normal/Large Sample conditions for constructing a confidence interval for a difference between two means.
- Calculate a C% confidence interval for a difference between two means.
- Use the four-step process to construct and interpret a confidence interval for the difference between two means.
- State hypotheses and check conditions for performing a significance test about a difference between two means.
- Calculate the standardized test statistic and P-value for a significance test about a difference between two means.
- Use the four-step process to perform a significance test about a difference between two means.
- Use a graph to analyze the distribution of differences in a set of paired data.
- Calculate the mean and standard deviation of the differences in a set of paired data and interpret the mean difference.
- Use the four-step process to construct and interpret a confidence interval for a mean difference.
- Determine whether you should use two-sample t procedures for inference about $\mu_1 - \mu_2$ or paired t procedures for inference about μ_{diff} in a given setting.
- State hypotheses for a test about the distribution of a categorical variable.
- Calculate expected counts for a test about the distribution of a categorical variable.
- Calculate the test statistic for a test about the distribution of a categorical variable.
- State hypotheses for a test about the relationship between two categorical variables.
- Calculate expected counts for a test about the relationship between two categorical variables.
- Calculate the test statistic for a test about the relationship between two categorical variables.
- Check conditions for a test about the relationship between two categorical variables.
- Calculate the P-value for a test about the relationship between two categorical variables.
- Use the four-step process to perform a chi-square test for association.
- Check the conditions for inference about the slope of a least-squares regression line.
- Calculate a C% confidence interval for the slope of a least-squares regression line.

- Use the four-step process to construct and interpret a confidence interval for the slope of a least-squares regression line.
- State hypotheses for performing a significance test about the slope of a least-squares regression line.
- Calculate the standardized test statistic and P-value for a significance test about the slope of a least-squares regression line.
- Use the four-step process to perform a significance test about the slope of a least-squares regression line.

Learning Activities:

- *see StatsMedic- 180 Days of Intro Stats for suggested small group activities*
  - *Is yawning contagious? : Students will describe the shape, center, and variability of the sampling distribution of a difference between two sample proportions.*
  - *Does memory training help? : Students will use a graph to analyze the distribution of differences in a paired data set and calculate the mean and standard deviation of the differences in a paired data set.*
  - Which color M&M is the most common? :State hypotheses for a test about the distribution of a categorical variable.
- see *Statistics and Probability with Applications* for suggested activities
  - I've Got to Fly
  - Sampling M&M's Candies
  - Inference Project

Assessment Evidence

Formative Assessments:

- Khan Academy skills from these units in the Statistics and Probability Course:
  - Two-sample inference for the difference between groups
  - Inference for categorical data (chi-square tests)
  - Advanced regression

Summative Assessments:

- Students will create a question about a topic of interest, collect the appropriate data and perform the four step process to use the data to answer the question. (This assessment could be completed multiple times using both categorical and quantitative data.) Students will create a display of their procedure and findings, similar to the project described here.

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Standards for Mathematical Practice
1. Make sense of problems and persevere in solving them Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. Older students might, depending on the context of the problem, transform algebraic expressions or change the viewing window on their graphing calculator to get the information they need. Mathematically proficient students can explain correspondences between equations, verbal descriptions, tables, and graphs or draw diagrams of important features and relationships, graph data, and search for regularity or trends. Younger students might rely on using concrete objects or pictures to help conceptualize and solve a problem. Mathematically proficient students check their answers to problems using a different method, and they continually ask themselves, “Does this make sense?” They can understand the approaches of others to solving complex problems and identify correspondences between different approaches.
2. Reason abstractly and quantitatively Mathematically proficient students make sense of quantities and their relationships in problem situations. They bring two complementary abilities to bear on problems involving quantitative relationships: the ability to *decontextualize*—to abstract a given situation and represent it symbolically and manipulate the representing symbols as if they have a life of their own, without necessarily attending to their referents—and the ability to *contextualize*, to pause as needed during the manipulation process to probe into the referents for the symbols involved. Quantitative reasoning entails habits of creating a coherent representation of the problem at hand; considering the units involved; attending to the meaning of quantities, not just how to compute them; and knowing and flexibly using different properties of operations and objects.
3. Construct viable arguments and critique the reasoning of others Mathematically proficient students understand and use stated assumptions, definitions, and previously established results

in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. They reason inductively about data, making plausible arguments that take into account the context from which the data arose. Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and—if there is a flaw in an argument—explain what it is. Elementary students can construct arguments using concrete referents such as objects, drawings, diagrams, and actions. Such arguments can make sense and be correct, even though they are not generalized or made formal until later grades. Later, students learn to determine domains to which an argument applies. Students at all grades can listen or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments.

4. Model with mathematics

Mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace. In early grades, this might be as simple as writing an addition equation to describe a situation. In middle grades, a student might apply proportional reasoning to plan a school event or analyze a problem in the community. By high school, a student might use geometry to solve a design problem or use a function to describe how one quantity of interest depends on another. Mathematically proficient students who can apply what they know are comfortable making assumptions and approximations to simplify a complicated situation, realizing that these may need revision later. They are able to identify important quantities in a practical situation and map their relationships using such tools as diagrams, two-way tables, graphs, flowcharts and formulas. They can analyze those relationships mathematically to draw conclusions. They routinely interpret their mathematical results in the context of the situation and reflect on whether the results make sense, possibly improving the model if it has not served its purpose.

5. Use appropriate tools strategically

Mathematically proficient students consider the available tools when solving a mathematical problem. These tools might include pencil and paper, concrete models, a ruler, a protractor, a calculator, a spreadsheet, a computer algebra system, a statistical package, or dynamic geometry software. Proficient students are sufficiently familiar with tools appropriate for their grade or course to make sound decisions about when each of these tools might be helpful, recognizing both the insight to be gained and their limitations. For example, mathematically proficient high school students analyze graphs of functions and solutions generated using a graphing calculator. They detect possible errors by strategically using estimation

and other mathematical knowledge. When making mathematical models, they know that technology can enable them to visualize the results of varying assumptions, explore consequences, and compare predictions with data. Mathematically proficient students at various grade levels are able to identify relevant external mathematical resources, such as digital content located on a website, and use them to pose or solve problems. They are able to use technological tools to explore and deepen their understanding of concepts.

6. Attend to precision

Mathematically proficient students try to communicate precisely to others. They try to use clear definitions in discussion with others and in their own reasoning. They state the meaning of the symbols they choose, including using the equal sign consistently and appropriately. They are careful about specifying units of measure, and labeling axes to clarify the correspondence with quantities in a problem. They calculate accurately and efficiently, express numerical answers with a degree of precision appropriate for the problem context. In the elementary grades, students give carefully formulated explanations to each other. By the time they reach high school they have learned to examine claims and make explicit use of definitions.

7. Look for and make use of structure

Mathematically proficient students look closely to discern a pattern or structure. Young students, for example, might notice that three and seven more is the same amount as seven and three more, or they may sort a collection of shapes according to how many sides the shapes have. Later, students will see 7×8 equals the well-remembered$7 \times 5 + 7 \times 3$, in preparation for learning about the distributive property. In the expression $x^2 + 9x + 14$ older students can see the 14 as $2 \times 7$and the 9 as $2 + 7$. They recognize the significance of an existing line in a geometric figure and can use the strategy of drawing an auxiliary line for solving problems. They also can step back for an overview and shift perspective. They can see complicated things, such as some algebraic expressions, as single objects or as being composed of several objects. For example, they can see $5 - 3(x - y)^2$ as 5 minus a positive number times a square and use that to realize that its value cannot be more than 5 for any real numbers x and y.

8. Look for and express regularity in repeated reasoning

Mathematically proficient students notice if calculations are repeated, and look both for general methods and for shortcuts. Upper elementary students might notice when dividing 25 by 11 that they are repeating the same calculations over and over again, and conclude they have a repeating decimal. By paying attention to the calculation of slope as they repeatedly check

whether points are on the line through (1, 2) with slope 3, middle school students might abstract the equation $\frac{(y-2)}{(x-1)} = 3$. Noticing the regularity in the way terms cancel when expanding $(x - 1)(x + 1)$, $(x - 1)\left(x^2 + x + 1\right)$ and $(x - 1)\left(x^3 + x^2 + x + 1\right)$ might lead them to the general formula for the sum of a geometric series. As they work to solve a problem, mathematically proficient students maintain oversight of the process, while attending to the details. They continually evaluate the reasonableness of their intermediate results.