TOWNSHIP OF UNION PUBLIC SCHOOLS

MA550 - Advanced Placement Statistics

Curriculum Guide

2015

Curriculum Guide Approved

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The developer would like to thank Jason Mauriello, Supervisor of Mathematics for his lending his guidance and expertise throughout the development of this curriculum guide.

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Mission Statement

The Township of Union Board of Education believes that every child is entitled to an education designed to meet his or her individual needs in an environment that is conducive to learning. State standards, federal and state mandates, and local goals and objectives, along with community input, must be reviewed and evaluated on a regular basis to ensure that an atmosphere of learning is both encouraged and implemented. Furthermore, any disruption to or interference with a healthy and safe educational environment must be addressed, corrected, or when necessary, removed in order for the district to maintain the appropriate educational setting.

Philosophy Statement

The Township of Union Public School District, as a societal agency, reflects democratic ideals and concepts through its educational practices. It is the belief of the Board of Education that a primary function of the Township of Union Public School System is to formulate a learning climate conducive to the needs of all students in general, providing therein for individual differences. The school operates as a partner with the home and community.

Statement of District Goals

- Develop reading, writing, speaking, listening, and mathematical skills.
- Develop a pride in work and a feeling of self-worth, self-reliance, and self-discipline.
- Acquire and use the skills and habits involved in critical and constructive thinking.
- Develop a code of behavior based on moral and ethical principals.
- Work with others cooperatively.
- Acquire a knowledge and appreciation of the historical record of human achievement and failures and current societal issues.
- Acquire a knowledge and understanding of the physical and biological sciences.
- Participate effectively and efficiently in economic life and the development of skills to enter a specific field of work.
- Appreciate and understand literature, art, music, and other cultural activities.
- Develop an understanding of the historical and cultural heritage.
- Develop a concern for the proper use and/or preservation of natural resources.
- Develop basic skills in sports and other forms of recreation.

Course Description

This course will include the following content areas:

1. Interpreting Categorical and Quantitative Data

   Exploratory analysis of data makes use of graphical and numerical techniques to study patterns and departures from patterns. In examining distributions of one and two categorical and quantitative data, students should be able to detect important characteristics, such as shape, location, variability, and unusual values. From careful observations of patterns in data, students can generate conjectures about relationships among variables.

2. Gathering Data, Making Inferences, and Justifying Conclusions

   Both the type of analysis that is appropriate and the nature of conclusions that can be drawn from that analysis depend in a critical way on how the data was collected. Emphasis will be placed on sampling methods to include: simple random, stratified, systematic, and cluster sampling. Data must be collected according to a well-developed plan if valid information is to be obtained. Experiments must be designed with respect to blocking, blinding, the placebo effect, and methods of randomization.

   Making inferences from data can be thought of as the process of selecting a reasonable model and generalizing sample data to draw justifiable conclusions about the entire population.

3. Conditional Probability, Rules of Probability and Making Decisions based on Probability

   Recognize independence, the role it plays in calculating conditional probabilities and use them to interpret data. The rules of probability allow for the calculation of the probability of compound events in a uniform probability model. Calculate expected value and use it to solve problems and evaluate the outcomes of decisions.

Recommended Textbooks

Student Text:

Stats: Modeling the World AP* Edition (Bock Velleman DeVeaux) - Pearson

AP* Test Prep Series Workbook: 7 Main Topic Reviews and 4 Full Length Exams

Recommended Student Calculator:
TI 84 Plus Silver Edition Color

Additional Teacher Materials:
Amsco's AP* Statistics: Preparing for the Advanced Placement Exam Second Edition (Bohan)

Course Proficiencies

EACH STUDENT WILL BE ABLE TO:

- 1. Read and understand terminology in published statistical reports and journals
- 2. Create and interpret graphs from data and calculate descriptive statistics
- 3. Calculate and interpret correlation between two variables
- 4. Determine the influence of one variable on another by using regression methods
- 5. Identify the characteristics of and the differences between observational studies and experiments
- 6. Know the different ways of selecting samples from a population
- 7. Know how to design a valid statistical study and be aware of the biases that may exist
- 8. Calculate the probabilities of real world phenomena
- 9. Students will understand and use sampling distributions
- 10. Calculate and interpret confidence intervals in real world situations
- 11. Perform significance tests and draw valid conclusions from their findings
- 12. Perform and interpret chi-squared tests on categorical data
- 13. Perform non-parametric tests when other significance tests are deemed invalid
- 14. Select and perform the best statistical analysis possible for a specific real world situation

Curriculum Units

Unit 1: **Interpreting Categorical and Quantitative Data**

Unit 2: **Conditional Probability, Rules of Probability, and Making Decisions based on Probability**

Unit 3: **Gathering Data, Making Inferences, and Justifying Conclusions**

Pacing Guide AP Statistics
Semester I

Unit 1
Interpreting Categorical and Quantitative Data

	Chapters	# of days
Introduction to Statistics and How to Learn from Data	1	8
Exploring Data with Graphs and Descriptive Numerical Summaries	2-6	16
Association: Contingency, Correlation, and Regression	7-10	14

Unit 2
Conditional Probability, Rules of Probability, and Making Decisions based on Probability

Experiments and Sampling Methods	11-13	14
Probability in Our Daily Lives	14	16
Discrete and Continuous Probability Distributions	15-17	12

Pacing Guide – AP Statistics
Semester II

Unit 3

Gathering Data, Making Inferences and Justifying Conclusions	**Sections**	**# of days**
Sampling Distributions	18	8
Statistical Inference: Confidence Intervals	19,21	10
Statistical Inference: Significance Tests About Hypotheses	20,21-23	18
Analyzing the Association Between Categorical Variables: Chi-Square Tests	26	6
Analyzing Association Between Quantitative Variables: Inference for Regression Analysis	27	6
A.P Exam Review	Cumulative, Review WB	12
Multiple Regression	29	5
Nonparametric Statistics	Supplementary	10
Researching Statistics	Supplementary	5

Unit 1: Interpreting Categorical and Quantitative Data

Essential Questions	Instructional Objectives/ Skills and Benchmarks *(CPIs)*	Activities	Assessments
1. How can we construct and interpret graphical displays of distributions of univariate data? (stemplot, histogram, cumulative frequency plot) 2. How can we summarizing distributions of univariate data? 3. How can we compare distributions of univariate data (back-to-back stem plots and parallel boxplots)? 4. How can we explore bivariate data? 5. How can we explore categorical data?	1. Identify center, spread, clusters, outliers and other unusual features of univariate data by reading graphical representations. **S-ID2** 2. Calculate center, spread and position of univariate data **S-ID3** 3. Compare and contrast features of different univariate distributions. **S-ID3** 4. Analyze patterns in scatterplots, recognize correlation and linearity. Find least-squares regression line and verify its validity by checking residual plots, outliers, and influential points. **S-ID6** 5. Construct and interpret representations of categorical data. **S-ID5**	1. Instructor and student use of interactive computer software applet to demonstrate resistance of mean and median by outliers in a data set. 2. Use of correlation by eye computer applet designed to aid students in recognizing strength of correlation. 3. Use Microsoft Excel computer program to complete least squares regression project (See Appendix A) 4. Organize univariate data into logical graphical representations using the graphing calculator that can be used to make conclusions about univariate distributions. 5. Enter data into graphing calculator and run one variable statistics to find the mean, median, mode, range, standard deviation, percentiles, and z-scores for univariate data. 6. Estimate population percentages using normal distribution. Use calculators, spreadsheets, and tables to estimate areas under the normal curve 7. Check the validity of least-squares regression by analyzing patterns in residual plots 8. Fit a function to the data, use linear, quadratic and exponential functions fitted to data to solve problems in the context of the data. 9. Construct and interpret frequency tables, bar charts, and other representations of categorical data.	Use given data of test grades from the previous statistics test to answer questions 1-3 58, 89, 67, 99, 74, 91, 84, 86, 70, 73, 97, 61, 52, 88, 55, 12, 78, 60 1. Calculate mean, median, mode, range, and standard deviation of data. 2. Construct a stem leaf plot of the data. 3. Describe the distribution of the data. Calculate boundaries for and make mention of any outliers.

Unit 2: Conditional Probability, Rules of Probability, and Making Decisions based on Probability

Essential Questions	Instructional Objectives/ Skills and Benchmarks *(CPIs)*	Activities	Assessments
1. How can we use the Law of Large Numbers to understand probability? 2. How can we use the Addition rule, multiplication rule, conditional probability, and independence to find the probability of an event occurring? 3. How can we combine independent random variables 4. How can we use the normal distribution to understand probability? 5. How does the Central limit Theorem play a role in Sampling distributions? 6. What are the types of sampling distributions?	1. Interpret probability including long-run relative frequency interpretation. **S-CP2** 2. Find probabilities based on distributions of discrete random variables. **S-MD2** 3. Simulate the random behavior of events based on probability distributions. **S-MD1** 4. Calculate expected value and standard deviation of a random variable and linear transformations of a random variable. **S-ID6** 5. Differentiate between independent and dependent events.**S-CP2** 6. Identify properties of a normal distribution and use normal distribution tables **S-MD3**	1. Calculate probability based on both independent and dependent events 2. Find probability based on binomial and geometric random variables. Use graphing calculator functions binompdf and binomcdf to calculate binomial probabilities. 3. Find the mean and standard deviation for sums and differences of independent random variables. 4. Find probabilities based on normally distributed random variables. 5. Use sampling distributions reach conclusions about sample data.	1. A set of 2000 measurements has a symmetric, mound-shaped distribution. The mean Is 5.3 and the standard deviation is 0.7. Determine an interval that contains approximately 1360 data values. 2. In a group of 100 scouts who took the physical exam for summer camp, 20% had type A blood. Six percent had both blond hair and type A blood. Find the probability that one scout selected at random will have blond hair, given that the blood test reveals type A. 3. Rogers High will play Memorial High in baseball six times during the upcoming season. Assume the teams are of equal ability; that is, p = .5. Within the context of a binomial experiment, what is the probability that: Rogers will win 4 games and lose 2 Rogers will win *at least* 4 games?

	7. Reach conclusions about data using the following sampling distributions: a. Sampling distribution of a sample proportion b. Sampling distribution of a sample mean c. Students use computer applet for Central Limit Theorem to draw different sample sizes from a population and draw conclusions of the sampling distribution. d. Difference between two independent sample proportions e. Difference between two independent sample means f. Simulate sample distributions g. t-distribution h. chi-square distribution **S-MD-7**		

Unit 3: Gathering Data, Making Inferences, and Justifying Conclusions

Essential Questions	Instructional Objectives/ Skills and Benchmarks *(CPIs)*	Activities	Assessments
1. What are the methods of data collection? 2. How can we conduct random sampling using stratified, cluster, systematic, and simple random sampling? 3. How can we plan and conduct surveys to avoid bias? 4. How can we plan and conduct experiments? 5. When is it appropriate to use each of the following experimental techniques will be discussed: blocking, randomization, blinding, double blinding, replication, and the placebo effect?	1. Understand methods of data collection. **S-IC3** 2. Identify characteristics of a well-designed, well-conducted survey. **S-IC3** 3. Randomly select from a population in order to have a sample from which valid conclusions can be drawn.**S-IC4** 4. Identify different sampling methods and sources of bias. **S-IC4** 5. Identify characteristics of a well designed, well conducted experiment.**S-IC4** 6. Estimation a. Calculate and interpret confidence intervals for the following: i. a proportion ii. difference between two proportions iii. a mean iv. difference between two means (unpaired and paired) v. slope of a least squares regression line	1. Discussion of different types of bias including sampling bias, response bias, nonresponse bias, observer bias. 2. Plan a well-designed survey. 3. Draw an appropriate sample from the population. 4. Identify possible sources of bias. 5. Analyze sample data appropriately. 6. Complete Sample Survey Project (Project description in Appendix B) 7. Make conclusions about a population based on confidence intervals. 8. Use graphing calculator to create any confidence interval from data or from summary statistics.	1. Gathering Data Sample Problems i. A survey is to be conducted in your high school. There is to be a total of 40 students in the sample. Describe how you would choose the participants if: ii. There are to be the same number of freshman, sophomores, juniors, and seniors in the sample. iii. There are to be the same number of males and females in the sample. iv. There are no restrictions on the choice of the participants. v. Identify the source of the bias and specify the direction of the bias.

6. How can we generalize results and types of conclusions that can be drawn from observational studies, experiments, and surveys? 7. What is the relationship between point estimators and confidence intervals? 8. How can we conduct Tests of Significance? a. null and alternative hypotheses b. p-values c. concept and calculation of power	vi. prediction interval for predicted value **S-MD5** 7. Tests of significance a. Perform and interpret tests of significance for the following: i. a proportion ii. difference between two proportions iii. a mean iv. difference between two means (unpaired and paired) v. slope of a least squares regression line vi. chi-square tests for goodness of fit and independence **S-MD5**	9. Make conclusions about a population based on tests of significance. a. Set up correct null and alternative hypotheses based on the context of the problem. b. Verify assumptions for the test chosen are satisfied c. Use graphing calculator to calculate test statistic and P-value of the significance test. d. Draw conclusions of the test based on the test statistic and P-value in the context of the problem. 10. Find, read and summarize scholarly research journal articles in the student's intended area of college study. 11. Complete Final Project (Project description in Appendix C)	2. A flour company wants to know what fraction of Minneapolis households bake tier own bread. An SRS of 500 residential addresses is drawn and interviewers are sent to these addresses. The interviewers are employed during regular working hours on weekdays and they interview only during those hours. 3. Inference and Justifying Conclusions Problems i. A random sample of 64 students were asked to rate the school cafeteria food on a scale from 1 to 30. The sample mean was 22 and the standard deviation was 2.5. Determine the limits of a: 68% confidence interval 80% confidence interval 95% confidence interval

			4. Suppose your world history teacher had given a particular exam for several years and has determined that the scores are normally distributed and that the population mean score on the exam is 84 and the population standard deviation is 6. Her present class of 36 students obtains a mean score of 86. Should she retain the hypothesis that the class is representative of the population as defined by previous classes? Test at the 0.05 level with a two-tailed test to see if the null hypothesis is valid.

Appendix A: A.P. Baseball Statistics Project

Objective: To describe the association between quantitative variables and to predict values of the response variable based on the values of the explanatory variable. In baseball terms, we will find which variable is most correlated with winning and predict the number of wins based on this variable. All starred steps must be done on the computer using EXCEL.

Requirements

☆1. Collect the following baseball data from the _____ baseball season:
Hitting Stats: *Team, Runs, HR, SB, SLG, AVG*
Pitching Stats: *Wins, R, SO*

Directions (Warning: This will take a while to do and can be frustrating. Good luck!)

a. Go to www.mlb.com and drag the mouse over the "Stats" tab. Then click on "Historical".
b. Near the bottom left of the page, click on the gray box that says "Historical Team Stats".
c. Using the options on the left, go to the hitting stats for the given season.
d. Sort the data by team by clicking on the heading "Team".
e. Copy and paste the hitting stats into EXCEL.
f. Clean up the data and delete all unnecessary columns. (Be careful)
g. Now repeat steps c-f for the pitching stats.
h. Print out the data all on one page in landscape format.

☆2. Use EXCEL to construct 7 scatterplots that plots each quantitative variable as the x variable against *Wins* as the y variable. Add the regression equation (trend line) and r^2 value by right clicking on a point on the scatterplot and clicking "add trendline"; then on the options tab add the equation and r^2 value. Print them out all on the same page. On a separate page, discuss any associations visible in each scatterplot (linear or nonlinear, positive or negative).

3. If any of the scatterplots appear to be curved, attempt a transformation to make the scatterplot linear. Show the new transformed scatterplot and use it instead of the original curved one.

☆4. Calculate and interpret the correlation for each of these seven variables with *Wins*. Comment on the validity of the correlation.

5. Interpret r^2 for each of the seven variables with *Wins*.

6. Are there any influential points in any of your scatterplots? If so, identify them by *Team* name.

7. Based on the results of steps #2-6, identify which of the seven variables seems to be the best predictor of *Wins*? Why?

8. Use the regression line of the variable you selected in step #7 to predict the number of *Wins* the New York Mets ***should*** have had, based on this variable.

9. Calculate and interpret the residual for the New York Mets based on the same regression line.

☆10. Use EXCEL to construct a residual plot for the same regression you chose in step #7. Does this residual plot verify that the least squares regression line fits the data well? Explain. (Show the predicted values, residuals and residual plot all on the same page.)

☆ Add another variable defined by $(Runs^2 - R^2)$. Construct the scatterplot and calculate the correlation between this variable and *Wins*. This is one of the better-known

Appendix B: AP Statistics Sample Survey Group Project
Due: 12/13/10

Objective: Design and implement an observational study to answer your topic question.

Requirements

Each student must hand in their own individual project.
Topic questions must be approved by the teacher.
Steps 2-7 should be the same for every member in your group.
Steps 8-12 should be different for every member.

On your title page, write your name and topic question. Also list your group members.
Please number the requirements in your final report.

Group Project Requirements

1. Each person in your group must decide on an individual topic question with a common group theme.
2. Combine all the topic questions from your group into one survey. Think carefully about the wording of these questions. Include this survey in your individual report.
3. What is the population for your study?
4. What sampling method will your group use to gather your data? What will the sample size be? Explain why your group chose that sampling method over the others.
5. Explain exactly how the subjects for your sample will be chosen. Will the sample be representative of the population? Be as specific as possible.
6. Collect the sample based on the survey your group prepared and sampling method your group selected. (This step does not need to be included in the final written report.)
7. Discuss any problems that your group ran into with the sampling process. Are there any biases that may occur as a result of the sample your group collected? Explain. (It's OK to mention problems or biases that you find. In practice, almost no sample is without its share of problems. Just mention the issues your group ran into and how your group dealt with them.)

The group aspect of the project is complete. The rest of the project will be individual, using the data for your individual topic question only.

Individual Project Requirements

8. Display the data collected on your *individual* topic question from the survey.
9. Construct a table to display the data.
10. Make an appropriate graph based on your data.
11. If the data is categorical, calculate the relative frequency of each category.
    If the data is quantitative, calculate the mean, median, mode, standard deviation.
12. Summarize the conclusions that you found based on the graphs and calculations. Explain the results of the sample.

Results Presentation

Students must present their findings to the class in a clear and concise manner with emphasis on the use of proper statistical vocabulary and terminology.

Appendix C: AP Statistics Final Project

Overview
Each student will prepare a poster.
The project will include an analysis of data from an existing dataset or a dataset generated by the student. The end product is a poster (on 22 by 28 inch poster board) that will be presented to a group of fellow students at a poster session scheduled for **Monday, June 14 through Wednesday, June 16**. During the poster presentations you will also be responsible for reviewing the poster presentations of others in your class. Posters will be graded after the presentations are completed.

Proposal
A proposal for the project will be required. The proposal must be a single page that gives a brief statement of your topic, the issue or question you are addressing, the source of the data (be specific), how the data was (or will be) collected, the sample size, and the graphical and statistical analysis techniques that will be used.
The proposal will be due by **Friday, May 14**.

Poster Presentation Reviews
At the completion of each poster presentation, the other members of the class will independently review the poster and presentation by completing the attached review form (a blank review form is provided).

Analysis of Data
The project will consist of 1) locating or collecting data in your field of interest that will require both graphical displays and statistical analyses, 2) preparing a poster that presents the aforementioned graphical display(s) and results of statistical tests, 3) verbally presenting the poster to fellow students at a poster presentation session, and 4) reviewing the poster presentations of other class members.

Step 1 – Selection of the Dataset or Design of the Study

Identify a field of potential interest, such as medicine, biology, economics, sports, etc. The internet has a vast source of datasets on almost any subject. Just search for your favorite topic using an internet search engine. Be sure to select a dataset that has a clear description of its context (e.g. background, study design, specification of variables, etc.). Sports are a good source for datasets (e.g. try www.baseball-reference.com). If you have already collected your own dataset or plan on collecting your own data, you will need to be concerned about aspects of study design. What are the primary study objectives? What are the primary variables? How was the sample size determined? How were the individuals selected? How are you avoiding bias? What statistical techniques will be used? If you plan on collecting data from other individuals (e.g. surveying your fellow students), please see the instructor to discuss issues of consent and confidentiality before you start.

Step 2 – Conduct your Study and Analyze your Data

The best approach to data analysis is to have a clear plan that focuses on your primary objectives.
Your plan should include methods for understanding your data [graphs and tables] and the analysis [the analysis method(s), key graph(s) and table(s) reporting the analysis results].

Step 3 – Preparation of your Poster

The presentation should fit onto a 22 by 28 inch poster board, use a font size of 28 or higher throughout (for readability), and should consist of the following elements:

1) A brief descriptive title of the research topic.
2) If you used data collected by someone else, you should give a complete formal statement of the reference for the data.
   If you generated the dataset yourself, you should give a single sentence summary description of the dataset accompanied by the statement "collected and analyzed by (your name)". If someone else assisted you in the collection of the data, then their name should also be given.
3) An abstract giving the following:
   a. Background (10-40 words)
   b. Methods (10-40 words)
   c. Results (20-100 words)
   d. Conclusions (10-40 words)
4) A statement of your study design, indicating the specific source of the data, the sample size, and how the data was collected (50-100 words).
5) A table describing the key characteristics of your dataset (e.g. if you are reporting a clinical analysis, this would be a table giving summary statistics on the age, race, sex and disease characteristics of the patients in the study).

6) A graphical display(s) useful for understanding the results of your study. The most common type of graphical display is the histogram or bar chart.
7) A paragraph describing the concept/conclusions of the graphical display(s) (50-100 words).
8) The results of the main statistical tests you conducted. In general, the most common types of statistical analyses are t-tests, chi-square tests, and regression. Include all parts of the significance test or confidence interval.
9) A paragraph describing the concept/conclusions of the statistical test results (50-100 words).
10) A single paragraph describing the strengths (20-100 words) and weaknesses (20-100 words) of the graphical display(s) and statistical test results (e.g. weaknesses may involve a small number of subjects, suboptimal study design, unmet assumptions, or variables that you would have liked to control for, but were not available in your data).

Important notes

1. Focus on presenting only 1-2 analysis points clearly. Don't try to present lots of complex material. One of the goals of this project is for you to develop the skill to be able to present the results of an analysis in a clear, succinct manner that will maximize the likelihood that it will convince others of your main conclusions. Do not fill up your poster with unnecessarily complex detailed graphs, analyses and text.

2. Word limits and font sizes have been designed for this poster project to encourage the development of an effective poster. Please follow them.

3. If your current text and material doesn't fit onto the poster, your first thought should be to condense your text to just the essential elements. The skill of condensing text to fit within the word limits of professional journals is a skill nearly all will eventually need in their career. It is recommended that the student write at least twice as much text as needed for the poster and then condense it down to reach the word limits.

Text initially written to a target word limit often looks disjoint and sloppy. Also, please do not have any material hang over the edges of the poster.

4. Discussing strengths and weaknesses. Referring to the poster paragraph describing the strengths and weaknesses of the graphical display(s) and statistical test results (section 10), please carefully note the following points. Study weaknesses (e.g. suboptimal study design) should be identified using specific comments (rather than general comments) and a statement should be included that indicates how the problem could be solved in a practical manner. For example, a true experiment may not be possible, but it might be feasible to identify suitable individuals that could be used as controls. If there is a problem with a lack of testing of assumptions, the specific unreasonable assumptions should be identified, the method of testing or assessing the assumption should be identified, and a statement added giving your balanced judgment regarding the extent of potential impact the violation of this assumption would have on study results. If you can't show causality, describe why not? What causal relationship would you like to demonstrate if you could?

Poster Project Review Comments

Name of student who prepared the poster . _____

Please use the following rating scale for the 5 questions below
(5 – Outstanding, one of the best in the class; 4 - Very good, clear and well-done; 3 –Good, about average for the class; 2 – Fair, but could be improved; 1 – Some weaknesses, needs to be improved)

_____ Abstract
_____ Graphical display(s) and descriptive paragraph of the concept/conclusions
_____ Statistical tests (tables) and descriptive paragraph of the concept/conclusions
_____ Description of the strengths and weaknesses of the graphical display(s) and statistical test results
_____ Verbal presentation

Please give at least 20 words describing the strength of the poster and/or presentation.

_____
_____
_____

Please give at least 20 words of constructive criticism regarding the poster and/or presentation.

_____
_____
_____
_____

_____ Name of student who prepared this review

Appendix D: New Jersey Core Curriculum Content Standards
Statistics

Common Core State Standards S-ID, S-IC, S-CP and S-MD are used throughout curriculum. Students will develop their mathematical skills as well as their problem solving strategies and their ability to interpret information and data. They will become efficient and creative problem solvers and will acquire an understanding of mathematical concepts. Students will be able to solve problems numerically, graphically, and analytically. They will use technology to reinforce concepts and also as an efficient problem solving tool.

Statistics and Probability Overview

Interpreting Categorical and Quantitative Data

- Summarize, represent, and interpret data on a single count or measurement variable
- Summarize, represent, and interpret data on two categorical and quantitative variables
- Interpret linear models

Making Inferences and Justifying Conclusions

- Understand and evaluate random processes underlying statistical experiments
- Make inferences and justify conclusions from sample surveys, experiments and observational studies

Conditional Probability and the Rules of Probability

- Understand independence and conditional probability and use them to interpret data
- Use the rules of probability to compute probabilities of compound events in a uniform probability model

Using Probability to Make Decisions

- Calculate expected values and use them to solve problems
- Use probability to evaluate outcomes of decisions

Mathematical Practices

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.

Interpreting Categorical and Quantitative Data — S-ID

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.

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.
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; 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, quadratic, and exponential models.*
   b. Informally assess the fit of a function by plotting and analyzing residuals.
   c. *Fit a linear function for a scatter plot that suggests a linear association.*

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.

Making Inferences and Justifying Conclusions — S-IC

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?*

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.

Conditional Probability and the Rules of Probability S-CP

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.*

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

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?*

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).

Appendix E: New Jersey Scoring Rubric

Scoring Guide for Mathematics Open-Ended (OE) Questions
(Generic Rubric)

3-Point Response

The response shows complete understanding of the problem's essential mathematical concepts. The student executes procedures completely and gives relevant responses to all parts of the task. The response contains few minor errors, if any. The response contains a clear, effective explanation detailing how the problem was solved so that the reader does not need to infer how and why decisions were made.

2-Point Response

The response shows nearly complete understanding of the problem's essential mathematical concepts. The student executes nearly all procedures and gives relevant responses to most parts of the task. The response may have minor errors. The explanation detailing how the problem was solved may not be clear, causing the reader to make some inferences.

1-Point Response

The response shows limited understanding of the problem's essential mathematical concepts. The response and procedures may be incomplete and/or may contain major errors. An incomplete explanation of how the problem was solved may contribute to questions as to how and why decisions were made.

0-Point Response

The response shows insufficient understanding of the problem's essential mathematical concepts. The procedures, if any, contain major errors. There may be no explanation of the solution, or the reader may not be able to understand the explanation. The reader may not be able to understand how and why decisions were made.

The generic rubric above is used as a guide to develop specific scoring guides or rubrics for each of the open-ended (OE) questions that appear on the New Jersey fourth-grade (ESPA), eighth-grade (GEPA), and eleventh-grade (HSPA) proficiency assessments in Mathematics. The generic rubric helps ensure that students are scored in the same way for the same demonstration of knowledge and skills regardless of the test question.