CollegeBoard AP 50 YEARS

Setting a Policy for AP® Statistics

The purpose of this guide is to provide college faculty and administrators with research data, participation and performance data of AP® Statistics students, curricular content, and sample exam questions to facilitate the establishment of appropriate credit and placement policies for AP Statistics.

The Advanced Placement Program® (AP) provides motivated students with the opportunity to take college-level courses while still in high school. Students demonstrate their mastery of the curriculum by taking AP Exams—35 exams are available in 20 subject areas. In 2005, more than 1.2 million students took AP Exams worldwide. Of the 2.1 million AP Exams taken in 2005, about 77,000 were in Statistics. More than 3,000 colleges and universities, including many international institutions, accept qualifying AP Exam scores for credit, placement, or both.

Throughout its 50-year history, the AP Program has maintained high standards of rigor in its courses and exams. Since its inception, AP has been a respected force in American education due to the critical involvement of college and university faculty members.

Statistics Faculty Involvement in AP

College and university faculty members play a vital role in every stage of development and scoring of an AP course and exam, helping to ensure their high quality. Each AP discipline has its own Development Committee—composed of college and university professors and experienced AP teachers—that is responsible for creating the course guidelines and exam questions. College and university faculty members also serve as the Chief Readers, responsible for establishing the exam-scoring guidelines and overseeing the annual AP Reading of the free-response section for their academic discipline.

> "AP Statistics sits at the juncture of the high school and college curriculum. The modern content and active learning style that permeate the AP Statistics program have challenged some colleges to revamp their introductory statistics courses and to consider adding other courses in modern statistics for undergraduates who have the need, interest, and skill to go beyond the first course."
>
> —Richard Scheaffer, AP Statistics Development Committee former Chief Reader and former president of the American Statistical Association
> University of Florida

The College Board publication *AP and Higher Education* discusses the following topics at greater length: how to set an AP policy, AP research studies, the development of AP courses and exams, and the AP Exam scoring. For more information or to request a copy of this publication, please go to **apcentral.collegeboard.com/highered.**

How to Set an AP Policy

The College Board encourages higher education institutions to base their AP policy decisions on data and research, and recognizes that different institutions and departments will set different policies, based upon factors unique to their institution, student body, and academic discipline. The best way for colleges and universities to determine their AP credit and placement policies is to conduct their own research on the performance of AP and non-AP students at their own institution and in their own department.

Research on AP Student Performance

Research studies show that students who do well on an AP Exam are academically prepared to place out of a corresponding college course and move on to the next higher-level course in the discipline.

Taking the AP course and exam stimulates further interest in the subject area and encourages deeper disciplinary knowledge.

Research studies show that students who take the AP Exams are significantly more likely to take further course work in the same subject area than students who do not take the AP Exam. Higher scores on the AP Exam make this trend even more pronounced, with a greater likelihood of majoring or minoring in the discipline.

PDF copies research studies on AP student performance can be found at apcentral.collegeboard.com/colleges/research.

In addition to research studies on AP student performance, the College Board conducts college comparability studies to measure the degree to which the AP courses and exams are equivalent in content and difficulty to corresponding college courses. The AP Exam scoring rubric is established so that the lowest composite score that earns an AP grade of 5 is equivalent to the average score earned by college students who received grades of A in a comparable course. The lowest score that earns an AP grade of 4 is equivalent to the average B, and the lowest score that earns an AP grade of 3 is equivalent to the average C.

The research that the College Board conducts is intended to help institutions and academic departments as they establish appropriate AP policies. AP Central® (apcentral.collegeboard.com), the College Board's online home for AP professionals, contains other resources that may assist in this process, including the Course Description, released exam questions, and sample student responses at different levels of ability.

For more information go to:
apcentral.collegeboard.com/stats/exam

"In 1995 I received an invitation to attend a workshop to discuss a new AP course in statistics. My biggest concerns about the new AP Statistics program dealt with the quality of the course and the exam. After being involved with all aspects of the AP Statistics course over the last 11 years, I am confident that the AP Statistics course taken by high school students is at least equivalent to, and in many cases better than, the comparable course that is offered at colleges and universities. My experience at Kenyon College suggests that students who earn a 4 or 5 on the exam are prepared to enter our intermediate-level courses in statistics. Although a direct comparison is difficult because of differences in contact time, textbooks, vocabulary, format of the test, etc., two college comparability studies have been conducted; in every comparison from both studies the AP students did much better than the college students. Finally, anecdotal evidence from college and university faculty who score the exam suggests that the AP Statistics syllabus is ambitious and targets many students who may otherwise never take a college-level course in statistics."

—Brad Hartlaub
AP Statistics Development Committee Chief Reader
Kenyon College

AP Credit Policy Info on the Web

Information about AP credit and placement policies at more than 1,000 colleges and universities is available on the College Board's Web site at **www.collegeboard.com/ap/creditpolicy.**

AP Statistics Students, Course, and Exam

Participation and Performance Data for AP Statistics Students in 2005

Total Number of Schools Offering AP Statistics: 4,045

Table 1: AP Statistics Exam Score Distribution, 2005

EXAM GRADE	NUMBER OF EXAMINEES	% AT
Score of 5	9,649	12.6%
Score of 4	17,534	22.8%
Score of 3	19,389	25.3%
Score of 2	14,755	19.2%
Score of 1	15,459	20.1%
	76,786	100.0%

Figure 1: AP Statistics Exam Volume, 1997–2005

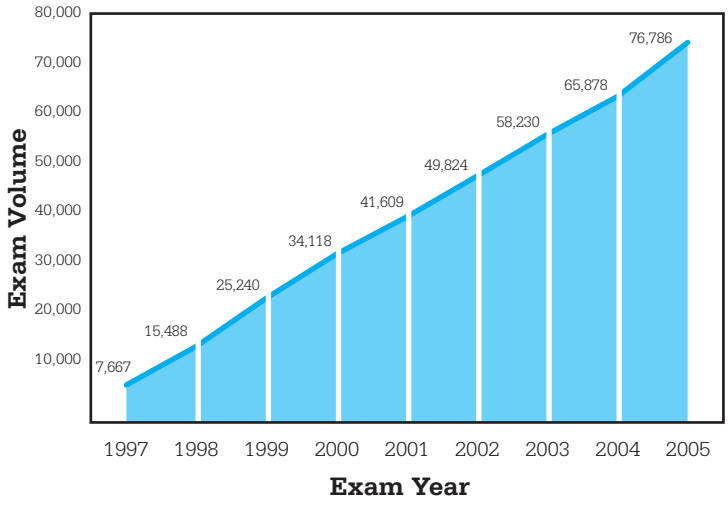


Figure 2: AP Statistics Exam Volume Percentage Increase 1998–2005

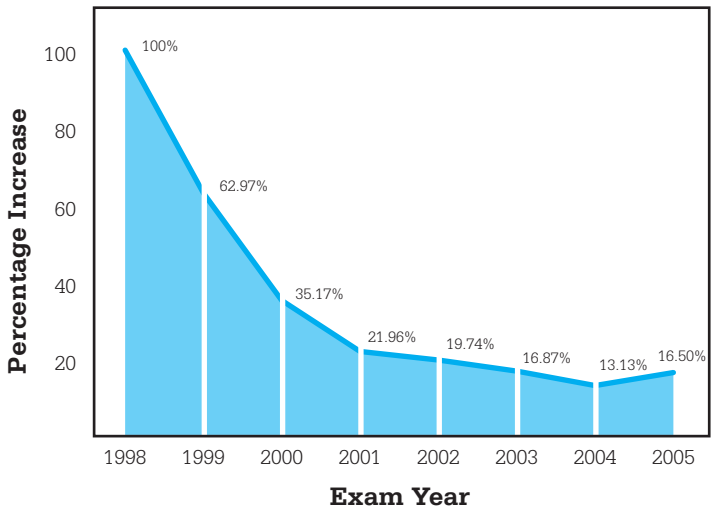
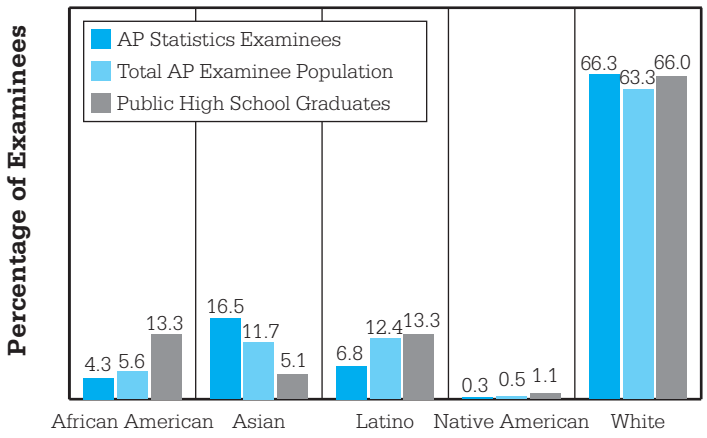


Figure 3: AP Statistics Examinees by Race and Ethnicity, 2005



The AP Statistics Course

The AP Statistics course is designed to provide students with a learning experience equivalent to that of an introductory college course in statistics. An introductory statistics course, similar to the AP Statistics course, is typically required for majors in the field of social sciences, health sciences, and business. Science, engineering, and mathematics majors usually take an upper-level calculus-based course in statistics, for which the AP Statistics course is an effective preparation. The purpose of the course is to introduce students to the major concepts and tools for collecting, analyzing, and drawing conclusions from data.

> "Taking AP Statistics has been an excellent experience. The knowledge and methodology I have learned in class has helped me to solve various real-life problems. In my science fair project titled "Judging a Book by Its Cover," for example, I compared the dimensions of the top-selling books in relation to the golden ratio, analyzing the data and conducting hypothesis tests with SAS software."
>
> —Tommy Li, AP Statistics student
> Plano West Senior High School

The Development Committee creates the guidelines for the AP Statistics course and designs the AP Exam. Periodically the Development Committee conducts curriculum surveys, sent to professors who teach the comparable college-level course, that help ensure that the AP Statistics course remains current with concepts and themes as taught in college and university classrooms. The Development Committee has identified four conceptual themes and a topic outline based upon those themes for the AP Statistics course. The percentages in parentheses for each theme indicate the coverage for that content area in the AP Statistics Examination.

I. Exploring Data: Describing patterns and departures from patterns (20–30 percent)

Exploratory analysis of data makes use of graphical and numerical techniques to study patterns and departures from patterns. Emphasis should be placed on interpreting information from graphical and numerical displays and summaries.

A. Constructing and interpreting graphical displays of distributions of univariate data (dotplot, stemplot, histogram, cumulative frequency plot)
   1. Center and spread
   2. Clusters and gaps
   3. Outliers and other unusual features
   4. Shape

B. Summarizing distributions of univariate data
   1. Measuring center: median, mean
   2. Measuring spread: range, interquartile range, standard deviation
   3. Measuring position: quartiles, percentiles, standardized scores (z-scores)
   4. Using boxplots
   5. The effect of changing units on summary measures

C. Comparing distributions of univariate data (dotplots, back-to-back stemplots, parallel boxplots)
   1. Comparing center and spread: within group, between group variation
   2. Comparing clusters and gaps
   3. Comparing outliers and other unusual features
   4. Comparing shapes

D. Exploring bivariate data
   1. Analyzing patterns in scatterplots
   2. Correlation and linearity
   3. Least-squares regression line
   4. Residual plots, outliers, and influential points
   5. Transformations to achieve linearity: logarithmic and power transformations

E. Exploring categorical data
   1. Frequency tables and bar charts
   2. Marginal and joint frequencies for two-way tables
   3. Conditional relative frequencies and association
   4. Comparing distributions using bar charts

II. Sampling and Experimentation: Planning and conducting a study (10–15 percent)

Data must be collected according to a well-developed plan if valid information on a conjecture is to be obtained. This plan includes clarifying the question and deciding upon a method of data collection and analysis.

A. Overview of methods of data collection
   1. Census
   2. Sample survey
   3. Experiment
   4. Observational study

B. Planning and conducting surveys
   1. Characteristics of a well-designed and well-conducted survey
   2. Populations, samples, and random selection
   3. Sources of bias in sampling and surveys
   4. Sampling methods, including simple random sampling, stratified random sampling, and cluster sampling

C. Planning and conducting experiments
   1. Characteristics of a well-designed and well-conducted experiment
   2. Treatments, control groups, experimental units, random assignments, and replication
   3. Sources of bias and confounding, including placebo effect and blinding
   4. Completely randomized design
   5. Randomized block design, including matched pairs design

D. Generalizability of results and types of conclusions that can be drawn from observational studies, experiments, and surveys

III. Anticipating Patterns: Exploring random phenomena using probability and simulation (20–30 percent)

Probability is the tool used for anticipating what the distribution of data should look like under a given model.

A. Probability
   1. Interpreting probability, including long-run relative frequency interpretation
   2. "Law of Large Numbers" concept
   3. Addition rule, multiplication rule, conditional probability, and independence
   4. Discrete random variables and their probability distributions, including binomial and geometric
   5. Simulation of random behavior and probability distributions
   6. Mean (expected value) and standard deviation of a random variable, and linear transformation of a random variable

B. Combining independent random variables
   1. Notion of independence versus dependence
   2. Mean and standard deviation for sums and differences of independent random variables

C. The normal distribution
   1. Properties of the normal distribution
   2. Using tables of the normal distribution
   3. The normal distribution as a model for measurements

D. Sampling distributions
   1. Sampling distribution of a sample proportion
   2. Sampling distribution of a sample mean
   3. Central Limit Theorem
   4. Sampling distribution of a difference between two independent sample proportions
   5. Sampling distribution of a difference between two independent sample means
   6. Simulation of sampling distributions
   7. t-distribution
   8. Chi-square distribution

IV. Statistical Inference: Estimating population parameters and testing hypotheses (30–40 percent)

Statistical inference guides the selection of appropriate models.

A. Estimation (point estimators and confidence intervals)
   1. Estimating population parameters and margins of error
   2. Properties of point estimators, including unbiasedness and variability
   3. Logic of confidence intervals, meaning of confidence level and confidence intervals, and properties of confidence intervals
   4. Large sample confidence interval for a proportion
   5. Large sample confidence interval for a difference between two proportions
   6. Confidence interval for a mean
   7. Confidence interval for a difference between two means (unpaired and paired)
   8. Confidence interval for the slope of a least-squares regression line

B. Tests of significance
   1. Logic of significance testing, null and alternative hypotheses; p-values; one- and two-sided tests; concepts of Type I and Type II errors; concept of power
   2. Large sample test for a proportion
   3. Large sample test for a difference between two proportions
   4. Test for a mean
   5. Test for a difference between two means (unpaired and paired)
   6. Chi-square test for goodness of fit, homogeneity of proportions, and independence (one- and two-way tables)
   7. Test for the slope of a least-squares regression line

Beginning in fall 2006, AP Statistics teachers and principals of schools where AP Statistics is taught must certify that their 2007-08 courses follow all the requirements stipulated by the Development Committee, including using a college-level textbook, in order to ensure that the AP course reflects college-level standards. By completing this AP Course Audit, high schools will receive individual licenses to label their statistics courses "AP." In fall 2007, colleges and universities will receive a list of all high schools authorized to use the "AP" designation for their statistics courses.

The AP Statistics Exam

The AP Statistics Exam includes two equally weighted sections: a 90-minute multiple-choice section testing proficiency in a wide variety of topics, and a 90-minute free-response section requiring the student to answer five open-ended questions and to complete an investigative task involving more extended reasoning. The free-response questions on the exam require students to use their analytical, organizational, and communication skills to formulate cogent answers. The questions provide students with an opportunity to relate two or more different content areas as they formulate a complete response or solution to a statistics or probability problem, and to demonstrate their mastery of statistics in a response format that requires the students to determine how they will organize and present each response. The purpose of the investigative task is not only to evaluate the student's understanding in several content areas, but also to assess his or her ability to integrate statistical ideas and apply them in a new context or in a nonroutine way. Students are permitted to use up to two graphing calculators with statistical capabilities during the exam.

AP Statistics free-response questions from recent exam years are listed below.

Question 1

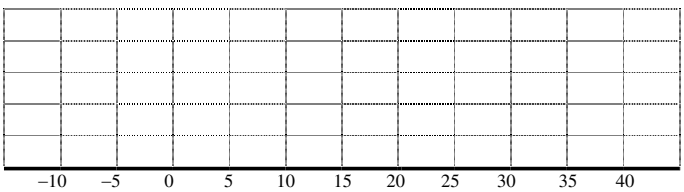
A consumer advocate conducted a test of two popular gasoline additives, A and B. There are claims that the use of either of these additives will increase gasoline mileage in cars. A random sample of 30 cars was selected. Each car was filled with gasoline and the cars were run under the same driving conditions until the gas tanks were empty. The distance traveled was recorded for each car.

Additive A was randomly assigned to 15 of the cars and additive B was randomly assigned to the other 15 cars. The gas tank of each car was filled with gasoline and the assigned additive. The cars were again run under the same driving conditions until the tanks were empty. The distance traveled was recorded and the difference in the distance with the additive minus the distance without the additive for each car was calculated.

The following table summarizes the calculated differences. Note that negative values indicate less distance was traveled with the additive than without the additive.

Additive	Values Below Q_1	Q_1	Median	Q_3	Values Above Q_3
A	–10, –8, –2	1	3	4	5, 7, 9
B	–5, –3, –3	–2	1	25	35, 37, 40

(a) On the grid below, display parallel boxplots (showing outliers, if any) of the differences of the two additives.



(b) Two ways that the effectiveness of a gasoline additive can be evaluated are by looking at either

- the proportion of cars that have increased gas mileage when the additive is used in those cars

or

- the mean increase in gas mileage when the additive is used in those cars.

i. Which additive, A or B, would you recommend if the goal is to increase gas mileage in the highest proportion of cars? Explain your choice.

ii. Which additive, A or B, would you recommend if the goal is to have the highest mean increase in gas mileage? Explain your choice.

Question 2

Researchers who are studying a new shampoo formula plan to compare the condition of hair for people who use the new formula with the condition of hair for people who use the current formula. Twelve volunteers are available to participate in this study. Information on these volunteers (numbered 1 through 12) is shown in the table below.

Volunteer	Gender	Age
1	Male	21
2	Female	20
3	Male	47
4	Female	60
5	Female	62
6	Male	61
7	Male	58
8	Female	44
9	Male	44
10	Female	24
11	Male	23
12	Female	46

(a) These researchers want to conduct an experiment involving the two formulas (new and current) of shampoo. They believe that the condition of hair changes with age but not gender. Because researchers want the size of the blocks in an experiment to be equal to the number of treatments, they will use blocks of size 2 in their experiment. Identify the volunteers (by number) that would be included in each of the six blocks and give the criteria you used to form the blocks.

(b) Other researchers believe that hair condition differs with both age and gender. These researchers will also use blocks of size 2 in their experiment. Identify the volunteers (by number) that would be included in each of the six blocks and give the criteria you used to form the blocks.

(c) The researchers in part (b) decide to select three of the six blocks to receive the new formula and to give the other three blocks the current formula. Is this an appropriate way to assign treatments? If so, describe a method for selecting the three blocks to receive the new formula. If not, describe an appropriate method for assigning treatments.

Question 3

Some boxes of a certain brand of breakfast cereal include a voucher for a free video rental inside the box. The company that makes the cereal claims that a voucher can be found in 20 percent of the boxes. However, based on their experiences eating this cereal at home, a group of students believes that the proportion of boxes with vouchers is less than 0.2. This group of students purchased 65 boxes of the cereal to investigate the company's claim. The students found a total of 11 vouchers for free video rentals in the 65 boxes.

Suppose it is reasonable to assume that the 65 boxes purchased by the students are a random sample of all boxes of this cereal. Based on this sample, is there support for the students' belief that the proportion of boxes with vouchers is less than 0.2 ? Provide statistical evidence to support your answer.

Question 4

A survey will be conducted to examine the educational level of adult heads of households in the United States. Each respondent in the survey will be placed into one of the following two categories:

- Does not have a high school diploma
- Has a high school diploma

The survey will be conducted using a telephone interview. Random-digit dialing will be used to select the sample.

(a) For this survey, state one potential source of bias and describe how it might affect the estimate of the proportion of adult heads of households in the United States who do not have a high school diploma.

(b) A pilot survey indicated that about 22 percent of the population of adult heads of households do not have a high school diploma. Using this information, how many respondents should be obtained if the goal of the survey is to estimate the proportion of the population who do not have a high school diploma to within 0.03 with 95 percent confidence? Justify your answer.

(c) Since education is largely the responsibility of each state, the agency wants to be sure that estimates are available for each state as well as for the nation. Identify a sampling method that will achieve this additional goal and briefly describe a way to select the survey sample using this method.

Question 5

A rural county hospital offers several health services. The hospital administrators conducted a poll to determine whether the residents' satisfaction with the available services depends on their gender. A random sample of 1,000 adult county residents was selected. The gender of each respondent was recorded and each was asked whether he or she was satisfied with the services offered by the hospital. The resulting data are shown in the table below.

	Male	Female	Total
Satisfied	384	416	800
Not Satisfied	80	120	200
Total	464	536	1,000

(a) Using a significance level of 0.05, conduct an appropriate test to determine if, for adult residents of this county, there is an association between gender and whether or not they were satisfied with services offered by the hospital.

(b) Is $\frac{800}{1{,}000}$ a reasonable estimate for the proportion of all adult county residents who are satisfied with the services offered by this hospital? Explain why or why not.

Question 6 (Investigative Question)

A pharmaceutical company has developed a new drug to reduce cholesterol. A regulatory agency will recommend the new drug for use if there is convincing evidence that the mean reduction in cholesterol level after one month of use is more than 20 milligrams/deciliter (mg/dl), because a mean reduction of this magnitude would be greater than the mean reduction for the current most widely used drug.

The pharmaceutical company collected data by giving the new drug to a random sample of 50 people from the population of people with high cholesterol. The reduction in cholesterol level after one month of use was recorded for each individual in the sample, resulting in a sample mean reduction and standard deviation of 24 mg/dl and 15 mg/dl, respectively.

(a) The regulatory agency decides to use an interval estimate for the population mean reduction in cholesterol level for the new drug. Provide this 95 percent confidence interval. Be sure to interpret this interval.

(b) Because the 95 percent confidence interval includes 20, the regulatory agency is not convinced that the new drug is better than the current best seller. The pharmaceutical company tested the following hypotheses.

$$H_0: \ \mu = 20 \ \text{versus} \ H_a: \ \mu > 20,$$

where μ represents the population mean reduction in cholesterol level for the new drug.

The test procedure resulted in a t-value of 1.89 and a p-value of 0.033. Because the p-value was less than 0.05, the company believes that there is convincing evidence that the mean reduction in cholesterol level for the new drug is more than 20. Explain why the confidence interval and the hypothesis test led to different conclusions.

(c) The company would like to determine a value L that would allow them to make the following statement.

We are 95 percent confident that the true mean reduction in cholesterol level is greater than L.

A statement of this form is called a one-sided confidence interval. The value of L can be found using the following formula.

$$L = \bar{x} - t^* \frac{s}{\sqrt{n}}$$

This has the same form as the lower endpoint of the confidence interval in part (a), but requires a different critical value, t^* . What value should be used for t^*?

Recall that the sample mean reduction in cholesterol level and standard deviation are 24 mg/dl and 15 mg/dl, respectively. Compute the value of L.

(d) If the regulatory agency had used the one-sided confidence interval in part (c) rather than the interval constructed in part (a), would it have reached a different conclusion? Explain.

How to Get Involved

There are many ways college and university faculty members can help maintain the high standards of the AP Program:

- Participate in a college comparability study
- Be an AP Reader
- Contribute multiple-choice test items for the AP Exam
- Become an AP Faculty Consultant

For more information, please go to: **apcentral.collegeboard.com/highered/getinvolved**

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The College Board: Connecting Students to College Success

The College Board is a not-for-profit membership association whose mission is to connect students to college success and opportunity. Founded in 1900, the association is composed of more than 5,000 schools, colleges, universities, and other educational organizations. Each year, the College Board serves seven million students and their parents, 23,000 high schools, and 3,500 colleges through major programs and services in college admissions, guidance, assessment, financial aid, enrollment, and teaching and learning. Among its best-known programs are the SAT®, the PSAT/NMSQT®, and the Advanced Placement Program® (AP®). The College Board is committed to the principles of excellence and equity, and that commitment is embodied in all of its programs, services, activities, and concerns. For further information, visit www.collegeboard.com.

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