CollegeBoard
Advanced Placement
Program

AP® Statistics

Teacher's Guide

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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 5,400 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.

Contents

Welcome Letter from the College Board

Dear AP® Teacher:

Whether you are a new AP teacher, using this AP Teacher's Guide to assist in developing a syllabus for the first AP course you will ever teach, or an experienced AP teacher simply wanting to compare the teaching strategies you use with those employed by other expert AP teachers, we are confident you will find this resource valuable. We urge you to make good use of the ideas, advice, classroom strategies, and sample syllabi contained in this Teacher's Guide.

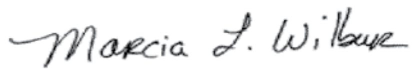
You deserve tremendous credit for all that you do to fortify students for college success. The nurturing environment in which you help your students master a college-level curriculum—a much better atmosphere for one's first exposure to college-level expectations than the often large classes in which many first-year college courses are taught—seems to translate directly into lasting benefits as students head off to college. An array of research studies, from the classic 1999 U.S. Department of Education study *Answers in the Tool Box* to new research from the University of Texas and the University of California, demonstrate that when students enter high school with equivalent academic abilities and socioeconomic status, those who develop the content knowledge to demonstrate college-level mastery of an AP Exam (a grade of 3 or higher) have much higher rates of college completion and have higher grades in college. The 2005 National Center for Educational Accountability (NCEA) study shows that students who take AP courses have much higher college graduation rates than students with the *same* academic abilities who do not have that valuable AP experience in high school. Furthermore, a Trends in International Mathematics and Science Study (TIMSS, formerly known as the Third International Mathematics and Science Study) found that even AP Calculus students who score a 1 on the AP Exam are significantly outperforming other advanced mathematics students in the United States, and they compare favorably to students from the top-performing nations in an international assessment of mathematics achievement. (Visit AP Central® at http://apcentral.collegeboard.com for details about these and other AP-related studies.)

For these reasons, the AP teacher plays a significant role in a student's academic journey. Your AP classroom may be the only taste of college rigor your students will have before they enter higher education. It is important to note that such benefits cannot be demonstrated among AP courses that are AP courses in name only, rather than in quality of content. For AP courses to meaningfully prepare students for college success, courses must meet standards that enable students to replicate the content of the comparable college class. Using this AP Teacher's Guide is one of the keys to ensuring that your AP course is as good as (or even better than) the course the student would otherwise be taking in college. While the AP Program does not mandate the use of any one syllabus or textbook and emphasizes that AP teachers should be granted the creativity and flexibility to develop their own curriculum, it is beneficial for AP teachers to compare their syllabi not just to the course outline in the official AP Course Description and in chapter 3 of this guide, but also to the syllabi presented on AP Central, to ensure that each course labeled AP meets the standards of a college-level course. Visit AP Central at apcentral.collegeboard.com for details about the AP Course Audit, course-specific Curricular Requirements, and how to submit your syllabus for AP Course Audit authorization.

As the Advanced Placement Program® continues to experience tremendous growth in the twenty-first century, it is heartening to see that in every U.S. state and the District of Columbia, a growing proportion of high school graduates have earned at least one grade of 3 or higher on an AP Exam. In some states, between 18 and 21 percent of graduating seniors have accomplished this goal. The incredible efforts of

AP teachers are paying off, producing ever greater numbers of college-bound seniors who are prepared to succeed in college. Please accept my admiration and congratulations for all that you are doing and achieving.

Sincerely,



Marcia Wilbur
Executive Director, Curriculum and Content Development
Advanced Placement Program

Equity and Access

In the following section, the College Board describes its commitment to achieving equity in the AP Program.

Why are equitable preparation and inclusion important?

Currently, 40 percent of students entering four-year colleges and universities and 63 percent of students at two-year institutions require some remedial education. This is a significant concern because a student is less likely to obtain a bachelor's degree if he or she has taken one or more remedial courses.[1]

Nationwide, secondary school educators are increasingly committed not just to helping students complete high school but also to helping them develop the habits of mind necessary for managing the rigors of college. As *Educational Leadership* reported in 2004:

> The dramatic changes taking place in the U.S. economy jeopardize the economic future of students who leave high school without the problem-solving and communication skills essential to success in postsecondary education and in the growing number of high-paying jobs in the economy. To back away from education reforms that help all students master these skills is to give up on the commitment to equal opportunity for all.[2]

Numerous research studies have shown that engaging a student in a rigorous high school curriculum such as is found in AP courses is one of the best ways that educators can help that student persist and complete a bachelor's degree.[3] However, while 57 percent of the class of 2004 in U.S. public high schools enrolled in higher education in fall 2004, only 13 percent had been boosted by a successful AP experience in high school.[4] Although AP courses are not the only examples of rigorous curricula, there is still a significant gap between students with college aspirations and students with adequate high school preparation to fulfill those aspirations.

Strong correlations exist between AP success and college success.[5] Educators attest that this is partly because AP enables students to receive a taste of college while still in an environment that provides more support and resources for students than do typical college courses. Effective AP teachers work closely with their students, giving them the opportunity to reason, analyze, and understand for themselves. As a result, AP students frequently find themselves developing new confidence in their academic abilities and discovering their previously unknown capacities for college studies and academic success.

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1. Andrea Venezia, Michael W. Kirst, and Anthony L. Antonio, *Betraying the College Dream: How Disconnected K–12 and Postsecondary Education Systems Undermine Student Aspirations* (Palo Alto, Calif.: The Bridge Project, 2003): 8.

2. Frank Levy and Richard J. Murnane, "Education and the Changing Job Market." *Educational Leadership* 62(2) (October 2004): 83.

3. In addition to studies from University of California–Berkeley and the National Center for Educational Accountability (2005), see the classic study on the subject of rigor and college persistence: Clifford Adelman, *Answers in the Tool Box: Academic Intensity, Attendance Patterns, and Bachelor's Degree Attainment* (Washington, D.C.: U.S. Department of Education, 1999).

4. *Advanced Placement Report to the Nation* (New York: College Board, 2005).

5. Wayne Camara, "College Persistence, Graduation, and Remediation," *College Board Research Notes* (RN-19) (New York: College Board, 2003).

Which students should be encouraged to register for AP courses?

Any student willing and ready to do the work should be considered for an AP course. The College Board actively endorses the principles set forth in the following Equity Policy Statement and encourages schools to support this policy.

> The College Board and the Advanced Placement Program encourage teachers, AP Coordinators, and school administrators to make equitable access a guiding principle for their AP programs. The College Board is committed to the principle that all students deserve an opportunity to participate in rigorous and academically challenging courses and programs. All students who are willing to accept the challenge of a rigorous academic curriculum should be considered for admission to AP courses. The Board encourages the elimination of barriers that restrict access to AP courses for students from ethnic, racial, and socioeconomic groups that have been traditionally underrepresented in the AP Program. Schools should make every effort to ensure that their AP classes reflect the diversity of their student population.

The fundamental objective that schools should strive to accomplish is to create a stimulating AP program that academically challenges students and has the same ethnic, gender, and socioeconomic demographics as the overall student population in the school. African American and Native American students are severely underrepresented in AP classrooms nationwide; Latino student participation has increased tremendously, but in many AP courses Latino students remain underrepresented. To prevent a willing, motivated student from having the opportunity to engage in AP courses is to deny that student the possibility of a better future.

Knowing what we know about the impact a rigorous curriculum can have on a student's future, it is not enough for us simply to leave it to motivated students to seek out these courses. Instead, we must reach out to students and encourage them to take on this challenge. With this in mind, there are two factors to consider when counseling a student regarding an AP opportunity.

1. Student motivation

Many potentially successful AP students would never enroll if the decision were left to their own initiative. They may not have peers who value rigorous academics, or they may have had prior academic experiences that damaged their confidence or belief in their college potential. They may simply lack an understanding of the benefits that such courses can offer them. Accordingly, it is essential that we not gauge a student's motivation to take AP until that student has had the opportunity to understand the advantages—not just the challenges—of such course work.

Educators committed to equity provide all of a school's students with an understanding of the benefits of rigorous curricula. Such educators conduct student assemblies and/or presentations to parents that clearly describe the advantages of taking an AP course and outline the work expected of students. Perhaps most important, they have one-on-one conversations with the students in which advantages and expectations are placed side by side. These educators realize that many students, lacking confidence in their abilities, will be listening for any indication that they should not take an AP course. Accordingly, such educators, while frankly describing the amount of homework to be anticipated, also offer words of encouragement and support, assuring the students that if they are willing to do the work, they are wanted in the course.

The College Board has created a free online tool, AP Potential™, to help educators reach out to students who previously might not have been considered for participation in an AP course. Drawing upon data based on correlations between student performance on specific sections of the PSAT/NMSQT® and performance on specific AP Exams, AP Potential generates rosters of students at your school who have a strong likelihood of success in a particular AP course. Schools nationwide have successfully enrolled many more students in AP than ever before by using these rosters to help students (and their parents) see themselves as having potential to succeed in college-level studies. For more information, visit http://appotential.collegeboard.com.

Actively recruiting students for AP and sustaining enrollment can also be enhanced by offering incentives for both students and teachers. While the College Board does not formally endorse any one incentive for boosting AP participation, we encourage school administrators to develop policies that will best serve an overarching goal to expand participation and improve performance in AP courses. When such incentives are implemented, educators should ensure that quality verification measures such as the AP Exam are embedded in the program so that courses are rigorous enough to merit the added benefits.

Many schools offer the following incentives for students who enroll in AP:

- Extra weighting of AP course grades when determining class rank
- Full or partial payment of AP Exam fees
- On-site exam administration

Additionally, some schools offer the following incentives for teachers to reward them for their efforts to include and support traditionally underserved students:

- Extra preparation periods
- Reduced class size
- Reduced duty periods
- Additional classroom funds
- Extra salary

2. Student preparation

Because AP courses should be the equivalent of courses taught in colleges and universities, it is important that a student be prepared for such rigor. The types of preparation a student should have before entering an AP course vary from course to course and are described in the official AP Course Description book for each subject (available as a free download at apcentral.collegeboard.com).

Unfortunately, many schools have developed a set of gatekeeping or screening requirements that go far beyond what is appropriate to ensure that an individual student has had sufficient preparation to succeed in an AP course. Schools should make every effort to eliminate the gatekeeping process for AP enrollment. Because research has not been able to establish meaningful correlations between gatekeeping devices and actual success on an AP Exam, the College Board **strongly discourages** the use of the following factors as thresholds or requirements for admission to an AP course:

- Grade point average
- Grade in a required prerequisite course
- Recommendation from a teacher

- AP teacher's discretion
- Standardized test scores
- Course-specific entrance exam or essay

Additionally, schools should be wary of the following concerns regarding the misuse of AP:

- Creating "Pre-AP courses" to establish a limited, exclusive track for access to AP
- Rushing to install AP courses without simultaneously implementing a plan to prepare students and teachers in lower grades for the rigor of the program

How can I ensure that I am not watering down the quality of my course as I admit more students?

Students in AP courses should take the AP Exam, which provides an external verification of the extent to which college-level mastery of an AP course is taking place. While it is likely that the percentage of students who receive a grade of 3 or higher may dip as more students take the exam, that is not an indication that the quality of a course is being watered down. Instead of looking at percentages, educators should be looking at raw numbers, since each number represents an individual student. If the raw number of students receiving a grade of 3 or higher on the AP Exam is not decreasing as more students take the exam, there is no indication that the quality of learning in your course has decreased as more students have enrolled.

What are schools doing to expand access and improve AP performance?

Districts and schools that successfully improve both participation and performance in AP have implemented a multipronged approach to expanding an AP program. These schools offer AP as capstone courses, providing professional development for AP teachers and additional incentives and support for the teachers and students participating at this top level of the curriculum. The high standards of the AP courses are used as anchors that influence the 6–12 curriculum from the "top down." Simultaneously, these educators are investing in the training of teachers in the pre-AP years and are building a vertically articulated, sequential curriculum from middle school to high school that culminates in AP courses—a broad pipeline that prepares students step by step for the rigors of AP so that they will have a fair shot at success in an AP course once they reach that stage. An effective and demanding AP program necessitates cooperation and communication between high schools and middle schools. Effective teaming among members of all educational levels ensures rigorous standards for students across years and provides them with the skills needed to succeed in AP. For more information about Pre-AP® professional development, including workshops designed to facilitate the creation of AP Vertical Teams® of middle school and high school teachers, visit AP Central.

Advanced Placement Program
The College Board

Participating in the AP Course Audit

Overview

The AP Course Audit is a collaborative effort among secondary schools, colleges and universities, and the College Board. For their part, schools deliver college-level instruction to students and complete and return AP Course Audit materials. Colleges and universities work with the College Board to define elements common to college courses in each AP subject, help develop materials to support AP teaching, and receive a roster of schools and their authorized AP courses. The College Board fosters dialogue about the AP Course Audit requirements and recommendations, and reviews syllabi.

Schools wishing to label a course "AP" on student transcripts must complete and return the subject-specific AP Course Audit form, along with the course syllabus, for all teachers of their AP courses. Approximately two months after submitting AP Course Audit materials, schools will receive a legal agreement authorizing the use of the "AP" trademark on qualifying courses. Colleges and universities will receive a roster of schools listing the courses authorized to use the "AP" trademark at each school.

Purpose

College Board member schools at both the secondary and college levels requested an annual AP Course Audit in order to provide teachers and administrators with clear guidelines on curricular and resource requirements that must be in place for AP courses and to help colleges and universities better interpret secondary school courses marked "AP" on students' transcripts.

The AP Course Audit form identifies common, essential elements of effective college courses, including subject matter and classroom resources such as college-level textbooks and laboratory equipment. Schools and individual teachers will continue to develop their own curricula for AP courses they offer—the AP Course Audit will simply ask them to indicate inclusion of these elements in their AP syllabi or describe how their courses nonetheless deliver college-level course content.

AP Exam performance is not factored into the AP Course Audit. A program that audited only those schools with seemingly unsatisfactory exam performance might cause some schools to limit access to AP courses and exams. In addition, because AP Exams are taken and exam grades reported after college admissions decisions are already made, AP course participation has become a relevant factor in the college admissions process. On the AP Course Audit form, teachers and administrators attest that their course includes elements commonly taught in effective college courses. Colleges and universities reviewing students' transcripts can thus be reasonably assured that courses labeled "AP" provide an appropriate level and range of college-level course content, along with the classroom resources to best deliver that content.

For More Information

You should discuss the AP Course Audit with your department head and principal. For more information, including a timeline, frequently asked questions, and downloadable AP Course Audit forms, visit apcentral .collegeboard.com/courseaudit.

Preface

Welcome! You are about to undertake a truly wonderful adventure. As an AP Statistics teacher, you stand at the beginning of a dynamic and exciting experience. Your students will analyze data using calculators and computers, conduct classroom experiments, and perform individual and group projects, making the AP course much different from the statistics course(s) you and I might have taken during our collegiate career. Your students will be active and engaged learners, and you will be right in the thick of it. It may seem a challenging task at times, but this guide and the broader statistics community are here to help you get your feet on the ground.

This course is the equivalent of a one-semester, introductory, noncalculus-based college course in statistics. Most students who take AP Statistics will also take college courses in the physical, biological, and social sciences, and the AP course will provide an excellent foundation for subsequent college work.

The purpose of this Teacher's Guide is to help new teachers prepare for and teach an AP Statistics course, as well as to offer more experienced instructors some fresh ideas to enliven their courses. I have tried to anticipate and answer many of your questions and to point you to various resources that your colleagues have found helpful. Scattered throughout the guide you will also find advice from other AP Statistics teachers who generously share what they have learned.

Chapter 1 begins with an overview by Kenneth Koehler from Iowa State University, chair of the AP Statistics Development Committee. His perspective on the role of AP Statistics and his insights about teaching the subject provide an excellent orientation to the course. Following the overview, you will find a description of what is included in the *AP Statistics Course Description* and a discussion of key concepts and skills that students should learn. The chapter closes with a free-response problem from the 2005 exam that highlights the connections between the Topic Outline and the AP Exam questions.

Chapter 2 contains a plethora of advice about getting started, with topics such as recruiting students, communicating with parents and colleagues, choosing a textbook, connecting with the broader statistics community, and using AP Central—a Web site that contains and links to many essential resources, such as the AP Statistics Electronic Discussion Group. The chapter concludes with three detailed examples of data analysis that are in the spirit of, but perhaps more extensive than, the investigative-type activities that students might be expected to encounter during the course.

Chapter 3 contains advice and guidance for creating your own syllabus. Eight sample syllabi from experienced statistics instructors (six high school teachers and two college statisticians) are included. I encourage you to read all of the syllabi, even those where the primary textbook differs from your own. Each has many gems to offer—ideas and tips for teaching tough concepts, activities, projects, and favorite AP Exam questions for review.

The AP Statistics Exam is the focus of chapter 4. Here you will find more advice from experienced teachers, as well as strategies for preparing your students for the exam. Finally, chapter 5 lists additional resources for teaching AP Statistics—books, videos, useful Web sites, suggested reading for the post–AP Exam period, statistical software, and references for your professional library.

Teaching statistics can be a very rewarding and exhilarating experience. It is a class in which you should always expect the unexpected, so you will need to stay on your toes. To understand everything from medicine to politics to sports, a citizen today must be statistically literate. You will never have to ask yourself, “Do my students really need to know this?”

In closing, I would like to offer my heartfelt thanks and recognition to the people who have contributed to this edition of the *AP Statistics Teacher’s Guide*. The instructors who shared their syllabi represent an impressive level of expertise and wisdom in teaching this course. The members of the AP Statistics Development Committee, who gave generously of their time and talent, offering comments on my early drafts, have markedly improved the book. Ellen Chien, during the time she worked at Educational Testing Service (ETS), was stellar in helping shepherd this guide to a timely completion. Finally, I must express my gratitude to Jeff Haberstroh of ETS for his guidance and support over the years. The success of AP Statistics is due in no small part to his behind-the-scenes dedication, work, and organization.

Michael Legacy

Michael Legacy is a teacher of AP Statistics and the K–12 math department chair at Greenhill School in Addison, Texas. He has served the AP community as a member of the AP Statistics Development Committee and as an AP Reader and Table Leader. He is also a frequent presenter at College Board conferences and AP Summer Institutes. Michael was statistics content editor for the Texas series *Laying the Foundation®: Connecting to AP Mathematics*, funded by the O’Donnell Foundation (Dallas), and a 2005 recipient of the Special Recognition Award from the College Board Southwestern Region for contributions to the AP Program.

Chapter 1
About AP Statistics

Overview: Past, Present, Future

The AP Statistics curriculum provides a modern introduction to working with data and statistical reasoning. It is equivalent to that found in the best college courses, with respect to the development of basic probability concepts for modeling randomness, collection and exploration of data, application of statistical reasoning in decision making, and emphasis on effective communication. Statistics, the science of gathering and interpreting data, is an essential part of most fields of science and many business and government activities. In addition to helping prepare students for advanced study and challenging careers, the ability to critically evaluate information has valuable lifelong benefits for making decisions about important personal issues such as diet, health care, and investments.

Recognizing its central importance, many colleges have made statistics a part of their general education requirements. Although some university students take their first statistics course within a statistics or mathematics department, many others receive their introduction to the subject through courses offered by programs in business, engineering, education, or one of the physical, biological, behavioral, environmental, or social sciences. The uses of statistics are quite varied, but they are all based on a fundamental set of concepts and procedures for gathering data, summarizing information, and making decisions in the face of uncertainty. The AP Statistics curriculum was developed from these fundamental concepts and procedures after many years of careful consideration by experienced college and secondary school statistics teachers.

AP Statistics emphasizes working with data to investigate questions of interest to students. The course makes use of mathematical concepts taught in algebra and geometry courses to quantify random variability, provide formulas for probabilities, and model relationships between measured quantities—but this is only one aspect of the curriculum. The broader emphasis is on clearly defining the questions to be investigated, gathering and organizing data, producing informative graphical and numerical summaries, modeling relationships, making decisions while accounting for uncertainty in the data, and clearly communicating results in the context of a study. Course projects may be developed from data students collect to investigate their own life experiences, data collected for other courses, or articles in the popular press. There are endless possibilities, including environmental issues, effectiveness of nutrition and exercise programs, medical studies, sports, marketing claims, trends in support for education, political opinion polls, and so on. This is what makes the course fun and exciting.

Whether it is taught in college or as an AP class, the first course in statistics is generally a very challenging one for both students and teachers. Do not be misled by the lack of a calculus requirement. The combination of talents demanded by this course provides significant challenges. For many students, this may be the first time they are required to integrate skills in communication, mathematics, data organization, computation, graphics, and inductive reasoning. They must also deal with precise use of statistical terminology that is based on words that can have quite different meanings in everyday language. Furthermore, there are often no exactly correct or incorrect solutions. Different approaches to analyzing the same data may reveal different insights, none of which is completely right or completely wrong, although some approaches may be more informative than others with respect to the objectives of a particular study. Providing students with meaningful learning experiences in making decisions and carefully communicating results, in addition to teaching basic statistical concepts and procedures, is a tall order, and there is no substitute for careful preparation.

Development of the AP Curriculum

In a broad sense, statistics is as old as recorded history, with governments and armies having recorded information on numbers of people, animals, and goods for many years. However, much of what we call modern statistics began to evolve through the work of agricultural and psychological researchers in the first part of the twentieth century. In 1925, R. A. Fisher published a landmark book, *Statistical Methods for Research Workers*, to introduce statistical methods to practicing scientists. George Snedecor's book, *Statistical Methods*, provided a textbook for a college course for prospective scientists in the 1930s. In the 1940s, rapid advances in industrial applications of statistical methodology were spurred by the large-scale needs of the military for reliable products. Much of this work was heavily based on probability models. In the late 1960s and the 1970s, John Tukey and Frederick Mosteller led a revolution that provided a new focus on the exploration of data. These efforts were aided by the development of calculators and computers that could provide the computational and graphical power needed to easily summarize results of data exploration. Application of statistical thinking continued to expand, and in the 1970s and 1980s textbooks introducing the modern introductory course in statistics to the undergraduate college curriculum began to appear.

With support from professional organizations, educators continued to explore and assess good practices for teaching introductory college courses in statistics. The development of AP Statistics was heavily influenced by the Quantitative Literacy program sponsored by the American Statistical Association (ASA) in the 1980s. In the early 1990s, George Cobb coordinated an e-mail focus group on statistics education as part of the Curriculum Action Project of the Mathematics Association of America (MAA). The ensuing report, published in the 1992 MAA volume *Heeding the Call for Change*, recommended greater use of active learning and greater emphasis on data and concepts of statistical thinking, with less theory and fewer recipes. The National Science Foundation funded numerous projects to implement these reforms. Led by Richard Scheaffer, an AP Statistics Task Force established by the College Board in 1992 began to develop a curriculum that would incorporate active learning into a data-orientated approach to teaching statistical thinking. The AP Statistics Development Committee held its first meeting in 1994, and the first AP Statistics Exam was given in 1997.

The Development Committee monitors new trends, as educators continue to explore and assess good practices for teaching introductory college courses in statistics. In 2003, the ASA provided support for the Guidelines for Assessment and Instruction in Statistics Education project (GAISE). This project consisted of two groups, one focused on K–12 education and one focused on introductory college courses. Building on past developments and a new survey about teaching introductory college courses in statistics, the 2005 GAISE report provided the following six basic recommendations for developing statistically literate students:

- Emphasize statistical literacy and develop statistical thinking.
- Use real data.
- Stress conceptual understanding rather than mere knowledge of procedures.
- Foster active learning in the classroom.

- Use technology for developing conceptual understanding and analyzing data.
- Use assessments to improve and evaluate student learning.

These recommendations are very much in line with the current AP Statistics curriculum.

The AP Curriculum

The Topic Outline in the 2009, 2010 *AP Statistics Course Description* gathers the components of a modern introduction to statistics into four major categories, the introductory headings of which are reproduced here. The percentages in parentheses for each content area indicate the coverage of that area in the AP Statistics Exam.

> I. Exploring Data: Describing patterns and departures from patterns (20%–30%)
> *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.*
>
> II. Sampling and Experimentation: Planning and conducting a study (10%–15%)
> *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.*
>
> III. Anticipating Patterns: Exploring random phenomena using probability and simulation (20%–30%)
> *Probability is the tool used for anticipating what the distribution of data should look like under a given model.*
>
> IV. Statistical Inference: Estimating population parameters and testing hypotheses (30%–40%)
> *Statistical inference guides the selection of appropriate models.*

Challenges and Opportunities

The AP Statistics curriculum emphasizes the use of real data and active learning as keys to the development of conceptual understanding. This approach has been very well received, and the program has experienced remarkable growth. Since the first AP Statistics Exam was given to about 7,500 students in 1997, the number of students taking the exam has steadily increased to more than 100,000 in 2008. As demand for AP Statistics courses continues to strengthen, providing training opportunities and support for teacher professional development remains an important challenge.

The impact of the AP Statistics program extends well beyond the course and exam, however. The growing number of high school teachers with experience in teaching statistics provides a valuable resource for the ongoing movement to incorporate more statistical thinking into the K–12 mathematics curriculum. Cooperation between high school and college teachers in developing and implementing the AP Statistics curriculum has inspired new active learning approaches to teaching statistical concepts that have been adopted by many colleges and universities. The growing number of students completing AP Statistics has led some colleges to develop a second undergraduate course in statistics to explore more advanced models and methods of data analysis and to help students gain a deeper understanding of concepts of sampling and study design.

We are living in a rapidly changing information age that places great value on the ability to collect, process, and evaluate data and to make decisions in the face of random uncertainty. AP Statistics teachers have an exciting opportunity to help students begin to acquire the essential skills to successfully deal with the challenges this age imposes on higher education and career development and to become informed citizens and effective, lifelong learners.

Kenneth J. Koehler
Chair, AP Statistics Development Committee
Iowa State University, Ames

Course Description Essentials

The first piece of essential reading for any teacher of AP Statistics is the *AP Statistics Course Description*, which provides a comprehensive view of the course and the exam. It can be purchased as a print publication from the online College Board Store (http://store.collegeboard.com) or downloaded for free from AP Central. A new teacher should read this completely, and all instructors should review it annually. It contains, among much other relevant information, the following important sections:

- An overview of the course, including philosophy and objectives
- The Topic Outline, indicating what is covered in the course
- An important statement on the use of technology
- A description of the exam format (different sections and time allocations for each)
- Sample multiple-choice and free-response questions and answers
- The formula sheets, charts, and tables that students have access to during the exam

The AP Statistics Development Committee, working with content experts at ETS, sets the direction of the program, updates the Course Description, and develops the examinations. This committee consists of three secondary school AP teachers and three faculty members from colleges and universities in different parts of the United States. Each member typically serves a three-year term. Having both high school and college teachers on the committee is helpful because they provide different perspectives: high school teachers offer valuable advice regarding realistic expectations when matters of content coverage, skills required, and clarity of phrasing are addressed, while college and university faculty ensure that the questions are at the appropriate level of difficulty for an introductory college course in statistics. In addition, the Chief Reader, a college faculty member who coordinates the scoring of the free-response questions at the annual Reading in June, aids in the development process. He or she attends every committee meeting to ensure that the free-response questions can be scored reliably.

The Course Description is also the place for communicating changes in the structure of the course. If the Development Committee were to refine the Topic Outline or add a new area, for example, that change would be announced here. However, the new topic would not appear on the examination until two years after the change had appeared in the Course Description.

As you read the Course Description, keep in mind the following points:

- Do not be tempted to go straight to the Topic Outline. It is important that you not skip over the introduction, the purpose, and the goals of the course. These statements and the content overview provide a structure and perspective that are the heart and soul of the course.

- The list of formulas and tables of values in the Course Description will be furnished to the students taking the exam. You will want to provide copies for students to use throughout the course. It might be helpful to print these out on different colored papers so that students can retrieve them easily from their notebooks. Some teachers also have laminated sets that students use for their tests during the year.
- Compare the Topic Outline to the table of contents of your textbook. The outline is organized thematically, whereas your textbook may have some other organizational approach. For example, some teachers start the year with sampling and experimental design even though most texts start with data analysis.
- Students are expected to use technological tools throughout the course. This essentially means graphing calculators with statistical capabilities and computers. Students should have a graphing calculator at all times during the year as well as for the exam itself. Read carefully the statement on technology in the Course Description, especially the final paragraphs on acceptable calculators and unacceptable enhancements to such calculators. For example, adding text to the calculator that gives information about the necessary conditions for inference or steps to execute some statistical process is forbidden.
- Although computers are fundamental tools of modern data analysis, it may not be possible for your students to gain much experience with them owing to competition for this limited resource in many schools. Recognizing this, it is critical that students have experience reading and interpreting standard computer output that might be provided on the exam. Several examples of this type of output are found among the multiple-choice and free-response questions in the Course Description. In addition, most introductory textbooks written for this course have many examples and exercises that use computer output from standard statistical packages such as *Minitab*®, *Data Desk*®, *JMP*®, or their student versions. Students are not necessarily required to understand every single part of the computer output (more output is sometimes given than is needed for the question), but they must be able to pick out, understand, and interpret those components that pertain to the subjects included in the Topic Outline. A salient point here is that most computer output is quite generic. The component parts of the various packages are easily recognizable to knowledgeable readers, and the individual differences are minor. This should be reassuring to students, as they can be confident that they will be able to interpret any computer output presented to them. Using different examples of output will help your students recognize the similarities among the commonly used software packages.
- The Topic Outline in the Course Description gives the scope of the coverage of the course. Although a good textbook will be your primary source of instruction and information, you will want to look for ways to enrich your course with outside resources, such as online applets and demonstrations, statistical news articles, videos, and data-gathering activities. Many of these supplemental sources are outlined in chapters 2 and 5 of this guide and are mentioned in the sample syllabi in chapter 3. Also, you will want to gather a variety of statistics textbooks to use as resources for additional examples and explanations.
- As a supplement to the Course Description, read the "Statistics Course Perspective" by Chris Olsen. This can be found on the AP Statistics Course Home Page (apcentral.collegeboard.com/stats) under *AP Statistics Course Information*.

The study of statistics blends the rigor, calculations, and deductive thinking of mathematics; the real-world examples and problems of the social sciences; the decision-making needs of business and medicine; and the laboratory method and experimental procedures of the natural sciences. Teaching AP Statistics—preparing motivational lessons with real examples of how statistics are used in practice, directing laboratory-type activities, designing experiments and surveys, helping students with the necessary technology, and, last but not least, thoroughly understanding statistics yourself—may require more preparation than any other course you have taught. These multidisciplinary aspects and applications of statistics are what eventually should make it the most rewarding of the courses you teach.

Key Concepts and Skills

The traditional study of mathematics consists of a sequence of lessons in which expressions are manipulated, equations are solved, algorithms are practiced, and a future payoff in problem-solving capability is promised the student. Today's conception of mathematics teaching, as formulated by the National Council of Teachers of Mathematics in its *Principles and Standards for School Mathematics*, envisions learning to solve real-life problems *concurrently* with instruction in mathematics, communication of useful mathematical reasoning, and active learning for students. Statistics, more than any of the mathematical courses that you have taught, is ideally suited for teaching and learning with an eye toward solving problems; it develops skills that will benefit students now and in their future roles as productive members of society. The AP Statistics course encourages the use of hands-on activities that students can pursue individually or in small groups. This active orientation both recognizes and insists that statistics is and should be more than calculations, tables, and rote responses to standard questions. Not only should an AP Statistics class act in concert with existing lab-oriented science classes, it should itself function as a lab-oriented course, with projects, data-gathering activities, and other hands-on experiences.

The general goals of the AP Statistics course, which are consistent with the course philosophy, are more about the relations and connections among the topics in the outline than the topics alone. For example, when students are preparing to solve an inference problem with data from two samples, it would be instructive to ask them how the data might have been collected. Do they think the data are from an observational study or from an experiment? This is an opportunity to review sampling and design vocabulary, even though it is a problem from an inference chapter. This is one of the purposes of the "investigative task" question in the free-response section of the AP Exam. Can students take what they have learned in the course and integrate that knowledge or apply it to a slightly different situation that has not been encountered in class? There is a much more extensive discussion of investigative tasks in chapter 4.

A Conceptual Framework for the Course

Instructional time should encourage students to step back and look at the whole picture. The short-term benefit of such a strategy is that they will be better able to function when confronted with context-rich, open-ended questions. The long-term benefits may be divided into two categories.

First, the instructional approach should go beyond "topics to be covered" and synthesize relations among the topics to provide a solid foundation for further academic study in statistics. The student preparing to study more advanced mathematics in college has a foundation in algebra, geometry, trigonometry, and precalculus constructed throughout his or her high school career. For many students, the analogous foundation in statistics will be provided in the AP Statistics course. Statistics, like mathematics, is a discipline rich in connections between parts that at first blush may not appear related. A solid instruction in statistics will help students see these connections.

A second long-term benefit is the preparation of the student to address and solve problems of a statistical nature long after the statistics class has finished. Experience tells us that a relatively disconnected set of topics will be forgotten as time passes. A set of topics cohesively organized into larger schema will be remembered longer and is more likely to be applied in future problem-solving situations.

The major components of such a cohesive framework are presented below. (You may notice that the order of presentation for the first two topics is reversed from the way they appear in the Topic Outline. This is because the statistical analysis process begins with thinking about how the data will be collected.)

Collection of Data: Sampling and Experimentation

For many teachers, this can be one of the most challenging units to teach. It is vocabulary-intensive and involves ideas that most students find difficult to grasp immediately. It also means that you as the teacher must do a lot of advance preparation: this is no place to "wing it." The terminology alone may be new for the first-time teacher of the course: treatments, control groups, experimental units, blinding, randomization, bias, placebo, and the concepts of replication, blocking, and confounding, among others. Make sure you understand the terms and their relevance in the scheme of things. This cannot be emphasized enough. If you are unsure, your students will be so as well. Some teachers in their first year or two of teaching this course have become more comfortable with the terminology by practicing lessons out loud before standing in front of the class.

One thing you might find helpful is to read the appropriate chapters from several textbooks. Note that the terminology is not completely standardized. Different books may use slightly different terms. This is okay since the focus in the course and on the exam is on understanding the underlying concepts. Also look at the scope of the experimental design questions on the AP Exam. Before you teach this unit, it might be instructive to actually go through all of the sampling and design questions on recent AP Exams (available at AP Central), write up your solution to each, carefully read the model answer given in the scoring guidelines, and then grade your work based on those standards. This exercise will help you review important concepts and vocabulary essential to the topic.

Give your students lots of opportunities to write about designs. Draw problems from different sources, such as those listed in the Supplementary Textbooks section in chapter 5 of this Teacher's Guide.

Students should understand that for valid statistical analyses of data, the method of data collection is critical. The way the data are collected will largely determine the subsequent analysis methodology; hence, careful attention should be given to this aspect of the study. The main issue should be how we can best answer the question at hand. The data collection method is especially important, for example, for survey questions in the social sciences. A survey consisting of vague or poorly worded questions will be difficult to interpret. The introduction of bias, in a myriad of forms, may derail any possible conclusions. Meaningful generalizations from samples to populations can only occur by virtue of an appropriate random sampling plan. Students should be able to describe a good random sampling plan or a randomization method in the case of experimentation. They should also be aware of the differences between observational studies and experiments, specifically with respect to the possibility of tentatively identifying a causal relation between variables and to the scope of any possible inferences that can be drawn from the data. In general, students should be able to plan a study in light of these considerations, as well as analyze and interpret such a study, recognize any limitations on the scope of inference, and offer constructive criticism, such as ways to improve the study.

Representation of Data

Numerical and graphical representations of data are the starting point for both descriptive and inferential statistical analysis. To get information from data, it has to be organized in ways that allow a researcher to ask questions of interest to her or him. Whether data result from observations of individual subjects, from experimentation, or possibly from a simulation, the center, variability, shape of the distribution, and unusual or interesting features of data are of fundamental importance. As well as providing information about the distribution of data values, simple pictures of data can also uncover measurement errors, provide reality checks on assumptions about populations, and suggest possible avenues for future analysis. Students should be able to represent data in a variety of forms, describe data distributions both graphically and numerically, make comparisons among distributions, use the data to check conditions necessary for inference, and draw conclusions.

Probability

Probability, the mathematics of chance and variability, provides foundational ideas such as events, independence, and probability distributions, as well as a mathematical language for communicating these ideas in the AP Statistics course. An understanding of simulations, sampling distributions as probability distributions, and statistics as random variables, together with a basic knowledge of the algebra of random variables, provides a conceptually solid foundation to answer questions such as, "Why do we add variances, and why does it matter?", and "How often would I get results like this if I used this method many times?"

An examination of the syllabi presented in chapter 3 will clearly indicate that this is not a probability course. What students do need is a working vocabulary that allows active classroom discussion of statistical ideas based on the underpinning probabilistic principles. Probability calculations are an essential element of statistical inference procedures. Since samples are subject to random variability, probability provides us with a way to quantify that variability and identify meaningful differences. For example, suppose you have two equal groups of surgery patients, with one group receiving the standard postsurgical care and the other group, a new postsurgical regimen. Suppose also that the difference in mean lengths of time it takes the two groups to recover from the surgery is markedly different. What is the probability that, owing simply to the random assignment of the patients, the difference in the mean lengths of recovery time for the two groups could be so large? In other words, what is the probability that, if the two treatments were equally effective, we would see a difference as large, or larger, than this one? This is called the *P*-value. Students must not only know how to calculate the *P*-value for an inference test but must also be able to interpret this value in the context of the problem.

Statistical Inference

Statistical inference is the central focus of the course. The successful student should have a firm grasp of the nature and logic of statistical inference as it unfolds in observational studies and experiments, from planning to *P*-value. Random sampling provides the basis for generalizing one's findings beyond the sample data at hand to the population of interest. Proper experimental design is a tool for controlling extraneous variables and reducing the ambiguities of experimental results. The formal inferential techniques of confidence intervals and hypothesis testing, the main methods for drawing conclusions about a population from sample data, lead to the assessment of the statistical significance of the study or experiment. Students must master the mechanics of choosing an appropriate inference method and computing the numerical values (either by hand or with a calculator), but more importantly, they should be able to communicate and interpret those results to a reader in a coherent conclusion.

Communication of Analysis, Methods, and Results

Even the best experimental design and statistical analysis are compromised if the reporting of methods and results is incomplete, ambiguous, or misleading—and students' responses to the AP Statistics Exam open-ended questions are not exempt from this principle. It may seem paradoxical to expect precision and clarity in a science devoted to the study of uncertainty, but the requirements of the AP Exam are consistent with the communication demands in modern statistical practice. Statistics involves explanation, interpretation, and translation. Students should be prepared to justify their choice of a particular procedure, explain their reasoning, and interpret their results, and they should be able to write an appropriate and complete conclusion. The value of effective communication in this course is emphasized in the Course Description, where "the dual importance of statistical knowledge and good communication" is cited in the discussion of holistic scoring of the AP Exam free-response questions (page 28 in the 2009, 2010 edition). Note that the scoring guidelines value both of these categories equally.

Relating This Approach to the AP Exam Questions

This philosophy of connecting topics and the building blocks described above guides the Development Committee in creating questions for the AP Statistics Exam. Let's examine a specific example to see how these elements are integrated into the questions. The following is free-response question 1 from the 2005 exam.

> The goal of a nutritional study was to compare the caloric intake of adolescents living in rural areas of the United States with the caloric intake of adolescents living in urban areas of the United States. A random sample of ninth-grade students from a high school in a rural area was selected. Another random sample of ninth graders from one high school in an urban area was also selected. Each student in each sample kept records of all food he or she consumed in one day.
>
> The back-to-back stemplot below displays the number of calories of food consumed per kilogram of body weight for each student on that day.

Urban		Rural
9 9 9 9 8 8 7 6	2	
4 4 3 1 0	3	2 3 3 4
9 7 6 6 5	3	5 6 6 6 7
2 0	4	0 2 2 2 4
	4	5 6 8 8 9
	5	1

Stem: tens
Leaf: ones

(a) Write a few sentences comparing the distribution of the daily caloric intake of ninth-grade students in the rural high school with the distribution of the daily caloric intake of ninth-grade students in the urban high school.

(b) Is it reasonable to generalize the findings of this study to all rural and urban ninth-grade students in the United States? Explain.

(c) Researchers who want to conduct a similar study are debating which of the following two plans to use.

Plan I: Have each student in the study record all of the food he or she consumed in one day. Then researchers would compute the number of calories of food consumed per kilogram of body weight for each student for that day.

Plan II: Have each student in the study record all of the food he or she consumed over the same 7-day period (one week). Then researchers would compute the average daily number of calories of food consumed per kilogram of body weight for each student during that 7-day period.

Assuming that the students keep accurate records, which plan, I or II, would better meet the goal of the study? Justify your answer.

Commentary

This problem asks students to compare the caloric intake for a random sample of 20 students from one rural high school with a random sample of 20 students from one urban high school. The variable measured was the number of calories per kilogram of body weight consumed in one day by each student. A back-to-back stemplot displayed the calories/kg consumed for each student on one day.

In part (a), students are asked to compare the distributions from both schools. Referring back to the key concepts above, this is "representation of data." The response should include a clear, correct, comparative statement for each of the three characteristics: shape, center (position), and spread. Comparative language must be used: for example, the median daily caloric intake of ninth-grade students in the rural school is higher than the median caloric intake for those in the urban school. Just making a list of the appropriate numbers for each distribution is insufficient to answer the question.

In part (b), students are asked whether it is reasonable to generalize the findings of the study to all rural and urban ninth-grade students in the United States. Here the question is getting at elements from "collection of data": the design of the study and the generalizability of the results. The response should clearly indicate that generalizing is not appropriate, because only one rural school and one urban school were used. The sampling unit was the school, not the subjects chosen for the study or the area from which the subjects were selected.

In part (c), students are presented with two possible sampling plans in consideration of a similar study. Plan I uses only one day; plan II uses a 7-day period with a 7-day average computed for the number of calories consumed by each student. Students are directed to choose the more appropriate plan and justify their choice. The student should indicate that plan II will better meet the goal of the study because it accounts for the effect of day-to-day variability and provides a more precise estimate of the average daily intake. A correct justification would indicate an understanding of what might cause systematic day-to-day variability in the difference between rural and urban students in the number of calories consumed on different days of the week (different amounts of calories consumed on a weekday versus a weekend day, for example). A student response that simply says that 7 days are better than one day is insufficient for justification.

As you look back over this question and response, please note several important details.

- The question draws from several parts of the course—data analysis and sampling design, in particular. This is characteristic of the integrative nature of many AP Statistics Exam questions. One part of a question might be about describing data, and another part might use the same data for conducting an inference procedure. One part may relate to inference and another part to sampling design. A question may start with a straightforward probability calculation that eventually takes the student through the binomial distribution and ends with a part about sampling distributions.
- There is not much in the way of computation. Students have calculators to help them, so most of the credit they can earn for a problem goes beyond the ability to correctly compute. Brilliant arithmetic will not overcome bad analysis and poor communication, but good analysis and communication can usually overcome errors in arithmetic.
- Communication is critical (much more about this in chapter 4). Note that the question asks students to explain and justify their choices. It is not sufficient to just write down the choice of plan II. To receive full credit, students must explain or justify in a direct comparison why this is a better choice than plan I.

The purpose of this chapter has been to explain what the AP Statistics course consists of, how it is reflected in the AP Exam, and the general conceptual skills it is expected to develop in students. This information has been assembled with broad strokes, giving a comprehensive view of where you are headed. The next chapter concentrates on specifics, with detailed advice on resources for new AP teachers, administrative issues, personal preparation for teaching, and data analysis models.

Chapter 2
Advice for AP Statistics Teachers

This chapter is devoted to providing a wide range of practical advice as you prepare to teach AP Statistics. It covers such concerns as the support needed from your school administration; recruitment of students; how to work with colleagues and parents; personal preparation for teaching the course; help provided for the new teacher by the College Board; and some model activities for your classroom. Do not be discouraged by the length of this chapter; it is long because there are many different aspects to consider in managing the course and dozens of ways to craft a successful learning vehicle. There is no single “right” way to teach this class. Remember also that the acquisition of resources, the improvement of your knowledge base, and your increased comfort level in teaching the course are long-term efforts. Think of this as a journey: you are about to take your first steps down a road that has been, for me, a most enjoyable trip.

Statistics, more than any other mathematical discipline, uses data gathered in other fields: the natural, biological, and social sciences; business, health, and politics; and even the humanities. In addition, the concepts and methods of statistics are used in many other disciplines to understand processes and make decisions. This state of affairs is reflected in today’s high school curriculum. Teachers of history, psychology, and other social science courses utilize graphic presentations of data, and natural science courses engage students in the techniques and reporting of laboratory experiments, frequently analyzing experimental data. AP Statistics develops a systematic overview of the subject, showing how data exploration, data production, and probability all come together in the weaving of sound inferential arguments. Laboratory scientists may teach that part of statistics that is the most useful in their discipline, whereas social scientists may teach a different subset. No single group of users of statistics is inclined to teach the larger picture of statistical reasoning and how the various techniques used by different disciplines fit into it. Teachers of statistics can provide that conceptual overview.

Tailoring the Course for Your School

Administrative Support

Teaching AP Statistics places unique demands on you and requires a supportive environment within your school as a whole and within the mathematics program in particular. You will need extra time to review the subject and develop a new course, and you will need funds for equipment, resources, and possibly computer software. Statistics draws its examples from other disciplines, and coordination with these disciplines will help to make the course a truly broad learning experience for students. Thus, the addition of AP Statistics to the academic program should be thought of as a schoolwide effort.

The optimal administrative support includes the following:

1. A smaller-than-average class size, especially while the course is being developed. Many schools recognize that some courses require more teacher time. English classes, with their many compositions, and laboratory or equipment-intensive courses frequently have enrollments that are below the norm. To paraphrase an epigram from the world of sports, mathematics is in contact with the real world; statistics collides with the real world. The AP Statistics teacher will have time-consuming duties equal to those classes just mentioned, and this should be supported by the administration.

2. Funding for you to upgrade your skills by taking college courses or attending an AP Summer Institute, and release time and funding for you to attend conferences and workshops during the school year. Many math teachers do not have a background in statistics commensurate with their training in mathematics. Administrators must recognize and support the commitment of math teachers to improve their knowledge of the statistics discipline and its pedagogy.

3. Sufficient equipment, including graphing calculators and computers with statistical software, as well as teaching devices such as tape measures, markers, dice, and cards, to meet the demands of the course.

4. Modern textbooks and accompanying teacher resources that reflect current best practices in statistics.

5. Resource materials, including supplementary textbooks and teaching materials, videos, and at least one journal devoted to statistics. Two excellent journals that should be considered for your library are *Chance*, an entertaining magazine of contemporary uses of statistics, and *STATS*, a journal for undergraduates interested in statistics. The American Statistical Association (www.amstat.org) publishes both. A K–12 school membership in the ASA is very reasonably priced.

6. Flexibility in scheduling so that students will have sufficient time to gather data and analyze the data using a computer if a lab and software are available. The teacher will have to be flexible and use the class time wisely.

Recruiting Students

In accordance with the College Board's Equity and Access policy (see page vii at the beginning of this guide), students taking AP Statistics should reflect the diversity of the overall school population. The College Board discourages "gatekeeping" by screening students based on test scores only. AP courses are not just for the smartest and most able students in the school. A highly motivated student who shows a commitment to excellence should be strongly considered for admittance to an AP class. A challenging, engaging, and rigorous class can many times inspire a student to achieve at a high level. The goal of breaking down the barriers to broaden participation in the AP Program is both laudable and achievable.

As an AP Statistics instructor, you will need to decide on the criteria for admission to your class. It is not easy for any teacher to make the decision that a student is mature enough, both mathematically and developmentally, for the rigors of college-level work. In the AP Statistics class, students will need to understand some concepts whose presentation is necessarily in a mathematical form and be able to follow and participate in discussions of these concepts. This requires more than just an algorithmic knowledge of the mathematics. The "mathematically mature" statistics student must be able to let the actual formulas recede into the background and have a certain comfort with the ideas and concepts behind the formulas. As a general rule of thumb, students should have been successful in second-year algebra in order to have the mathematical sophistication and disciplined work habits needed for AP Statistics. In addition, students should possess good mathematical reasoning ability and communication skills.

How do you encourage students to enroll in AP Statistics? I used to recruit by going to Algebra II classes around the end of January to talk about statistics and its place in many college degree programs, do a little demonstration on sampling or simulations, and encourage students to drop by my desk if they had questions or come visit one of my statistics classes. After a year or two, former students were my best ambassadors, via word-of-mouth. Another valuable resource is AP Potential, a free Web-based tool that allows schools to generate rosters of students who are likely to earn a grade of 3 or better on a given AP Exam. Many statistics teachers have successfully used this source by cross-referencing the mathematics and English lists generated by the system. In fact, some of my strongest statistics students were not necessarily my strongest math students but were among my better writers. For more information, read the overview at appotential.collegeboard.com. In order to use the service to access student lists, you must be registered with an access code from your school.

One goal of AP Statistics is to heighten interest in mathematics for those students who might otherwise drop out of mathematical studies at an earlier level. Many students complete three years of college preparatory mathematics by the end of eleventh grade and may not plan to enroll in any math course at all in their senior year. AP Statistics offers an interesting, productive way to keep these students involved with the discipline. Those who are interested in a social science major in college should know that it is statistics rather than calculus that is usually required. The experience of AP Statistics and AP Calculus teachers has been that AP Statistics is a popular option in high schools for a wide variety of students; it does not compete with existing math course offerings. Many students at my school are concurrently enrolled in precalculus and AP Statistics in either their junior or senior year. We also have some who are enrolled simultaneously in AP Statistics and AP Calculus (AB and BC).

Students who enroll in your class should do so with the understanding that they are strongly encouraged to take the AP Statistics Exam in May. Some schools make the exam a course requirement. The expectation should be that a substantial majority of students taking the course will master the material and will not then repeat the subject upon entrance to college.

Involving Parents

Our school has a long and successful involvement with AP courses, and students' parents and guardians are comfortable with the policies we have set. It is important nonetheless that there be open and ongoing communication with families. Maintaining a strong relationship with parents and guardians is extremely beneficial to the students' overall success.

At the start of the school year, I post a Topic Outline and course goals on the school's Web site. Additionally, I discuss the course and my expectations at our Meet the Teacher Night in September. During this time, I explain that this is not a typical math course. Students will be expected not only to deal with computations but to evaluate and communicate results in written form—not something they have likely experienced in previous math courses. I include several free-response questions to illustrate the level of analysis that will be required. I have also seen brochures that other statistics teachers have prepared and then used both to recruit students for the class and also to send home at the beginning of the year as an informational flyer.

Several years ago I went to our college counseling office and selected a dozen course catalogs from schools that our students typically attend. In about an hour, I had a list of a significant number of college majors that required at least one course in statistics as part of the degree program. I have this available for attendees at the Back to School Night, as well as for students who are interested in taking the course. It is also critical that you talk to your school counselors. It is to your advantage to make them allies and help them to better understand your course and what type of students would most benefit from enrolling.

A simple way to enlist parental support might be to prepare a brief description of important topics over the next three to five weeks, a summary of upcoming due dates for projects or outside work to be turned in, and a calendar of daily assignments. This could easily be posted on the school's Web site or sent out via regular mail. If you can do this every three weeks, or even every six weeks, it keeps the folks on the homefront in the loop. Parents are encouraged to contact me if they have questions about the program or concerns about their child's progress.

At my school, teachers write comments on the students three times a year (the midterm marking period in each twelve-week trimester). This is an arduous task, but it gives me an opportunity to inform parents about how their child is doing, to provide an overview of material that we are studying or will study, and to remind them of important deadlines for projects, unit tests, reviews, and the trimester exams. Although your school may not expect such extensive student commentary and parental communication, I think that staying in touch with families is an essential part of making your program successful. Getting parents and guardians to buy into your program and helping them to understand what is expected of their child in an AP class means that you will have more support at home and there will be fewer surprises if the going gets difficult.

Working with Colleagues

If AP Statistics is being added to a school curriculum that has existing AP courses, it is important that you speak with other AP teachers and the AP Coordinator to learn how the program works, how the course fits into the mathematics curriculum, and how Statistics compares to other AP courses at your school. Working in concert with colleagues in other subject areas engenders a positive and nurturing community spirit, helping to lessen the sense of isolation many statistics teachers sometimes experience.

Although our school does not have a math Vertical Team per se, we do have monthly Pre-K–12 math department meetings (about 24 people). Usually this one-hour meeting is devoted to a topic that is pertinent to all of us—for example, assessment or writing in the classroom. It is enlightening for upper school teachers to see that even in second grade our students are answering open-ended questions that are scored with a rubric. This is really not about "us" versus "them." It is also beneficial for elementary and middle school teachers to see that the fruits of their labor are reinforced in higher-level courses through the continued use of open-ended questions and assessment rubrics.

Many times elementary and middle school teachers think that their job is just to prepare students for high school, where the "real math" occurs. This is most unfortunate. It is important for those teachers to understand that without their excellent work in laying a foundation, our job in high school becomes that much harder. This year, for instance, our middle school is making a concerted effort to improve writing across all curricular areas. All teachers have access via our Web site to the curriculum map for each grade level (K–8) and each upper school course, and can see where a particular concept is introduced, reinforced, and eventually mastered.

AP teachers at my school are encouraged to visit other AP classes in science, history, and English. Substitutes are provided so that teachers can participate in these worthwhile endeavors, and these visiting days do not count against personal or professional days. AP teachers and those who use Pre-AP strategies are also encouraged to attend the two-day math conferences conducted by the College Board in the Southwestern Region. Teachers are expected to share what they have learned with the rest of the department.

Scheduling an AP Statistics Course

The Topic Outline in the Course Description presents an extensive array of concepts and skills, especially for those students who have not previously been exposed to probability and statistics. In addition to the exploratory techniques of modern data analysis that have recently been included in many secondary school curricula, the course must include introductions to topics in sampling, experimental design, and probability, and the thorough introduction to statistical inference found in most introductory college courses. In most situations, the AP Statistics course will require the equivalent of two semesters in order to teach the recommended subjects adequately. Some instructors have taught the course in one semester or two trimesters but have been hard-pressed to adequately teach the entire curriculum.

If your school has an accelerated block schedule, the fact that the AP Statistics Exam is given early in May might be the most important factor in your decision about when to offer the course. If the course is offered only in the spring, you will likely not complete the syllabus before the exam is administered, so the fall is a better bet—but in that case, students will need an ongoing review during the spring semester before taking the exam. In contrast, at many other schools the early May exam date leaves a significant amount of time between the exam and the end of the school year. The period after the exam can then be used for project work or to study topics beyond the AP Statistics syllabus.

Textbooks

The single most important decision you will make as you approach the teaching of AP Statistics is your choice of a textbook. The AP Statistics teacher must choose a text that contains appropriate content for the course, fits comfortably with modern technology, and is at a suitable reading and mathematical level. If you are new to the teaching of the subject, you should seek the counsel of experienced AP Statistics instructors, as well as university and college teachers actively involved in statistics education. The AP Statistics community has many experienced high school teachers, as well as a gratifying number of professors of statistics and professional statisticians who have been and will continue to be extremely helpful as you negotiate the shoals of textbook selection. (See chapter 5, Resources for Teachers, for a comprehensive review of the most often cited textbooks.) The AP Statistics Course Home Page (apcentral.collegeboard.com/stats) also contains up-to-date reviews of statistics textbooks, as well as other resources. Further valuable textbook advice may be solicited from experienced teachers of AP Statistics via the AP Statistics Electronic Discussion Group (EDG). Information about joining the EDG can be found later in this chapter.

Although you will rely on your primary textbook, you should also try to build a repository of supplementary materials. I encourage you to maintain a collection of textbooks for reference. The extra examples and different approaches that various authors provide can be valuable as you review course content and plan your lessons. Whereas statistics textbooks are published at particular points in time, the resources for an AP Statistics class are as timely and up-to-date as newspapers, newsmagazines, books, and scientific journals. Increasingly, newspapers are reporting insightfully on health, social concerns, and scientific issues; they are also including references to their sources (for example, “in today’s issue of the *New England Journal of Medicine* . . .”). Many of these sources have an online presence, and more detailed information than is reported in the newspapers may be found on their Web sites. Chapter 5 lists some of the resources that might be used to supplement the textbook. Classroom activities can also be enhanced by a range of contemporary educational materials, including videotapes and DVDs, computer- and Web-based instructional materials, CD-ROMs, and calculator-based measuring devices. Many textbooks targeted for AP Statistics also have extensive teacher-support materials to accompany the text, both in printed form and on the publishers' Web sites.

Technological Needs: Calculators and Computers

Modern technology, in the form of calculators and computers, has helped to redefine the nature of mathematics teaching and learning. Although economic issues will always be with us, and each district must struggle in its own way with its policies, calculators and computers should be a standard resource in an AP Statistics class. Calculators and computers each offer unique opportunities to a statistics student. In addition to the routine statistical calculation and graphics that calculators provide, their small size and mobility, combined with laboratory probes that can sample temperature, light, pH, and so forth, bring realistic experimentation and data gathering to the classroom. On the other end of the spectrum, the modern computer can store large data sets, allow interactive data analysis, and provide variety, speed, and visualization to simulations, thereby offering better understanding of the phrase "in the long run" as it applies to sampling distributions and the central limit theorem. Another important advantage of using computers is that statistical software packages can produce much more effective and informative visual displays of data than most calculators. (No matter the statistical package used, the computer output tends to be largely generic; that is, a scatterplot looks about the same with any package.) There is no balance of the two technologies that is perfect for all teachers and students in an AP Statistics class. This course has been taught successfully in situations with a wide range of calculator and computer availability.

It is expected that calculators will be used on the AP Exam; thus, students should have access to them throughout the course, both in class and for homework. While taking the exam, students will be expected to have a calculator with statistical computation and statistical graphics capability. A calculator with a typewriter keyboard will not be allowed. For a list of acceptable calculators, go to the AP Statistics Course Home Page, and click on *Calculator Policies for Mathematics and Science*. The fact that calculators are available means that an AP Statistics Exam question will not, for example, simply ask students to compute a standard deviation but will also (or instead) assess their understanding of what the standard deviation measures.

The use of a computer for statistical computing and statistical graphics is essential in the work of most statisticians. Although the availability of computers will enrich your course, the lack of access to a computer lab will not necessarily hinder students' understanding of statistics. However, it would be extremely helpful to have at least one computer in the classroom for demonstrations to help develop student understanding. There is no component of actual computer use on the AP Statistics Exam, but students are required to interpret computer output from standard statistical packages such as *Minitab*, *Data Desk*, and *JMP*, or their student versions.

As with textbook selection, the AP Statistics community can help with software selection if you are unfamiliar with existing packages. In many cases, producers of statistics software offer academic versions that are reasonably priced and can easily perform all data analysis tasks that arise in the AP Statistics course. Some statistics teachers have successfully used spreadsheet programs for statistical analyses. Generally, these programs are less satisfactory than programs designed specifically for statistics. There is also the *R* statistical package, which can be downloaded from the Web for free (www.r-project.org). It is a very powerful package that produces excellent graphs, and it also has a short guide to help students get started with basic data analysis.

An Applet a Day

The graphing calculator is an excellent tool for statistical calculations needed in the AP Statistics course. However, for visualizations and discovery two online applet resources that have become invaluable are Online Statistics (www.onlinestatbook.com) and the Rossman/Chance Applet Collection (www.rossmanchance.com/applets). The first site is totally interactive, with exercises and examples for students. Students not only choose an answer to a question but are expected to explain the answer. Solutions are provided. The simulations are wonderful, and students can truly see the central limit theorem come alive in their own creations. The full range of topics from any introductory statistics book is covered on this site.

The second site gives students a variety of ways to sample, using pennies or Reese's Pieces®, to name just two. Students really enjoy watching the "candy machine" select the colors. The interactivity allows students to change parameters and sample sizes, which truly facilitates the discovery approach to learning. Students can access these sites on their home computers, which is an added benefit when lab time is not available.

—Robin Levine-Wissing, Glenbrook North High School, Northbrook, Illinois

Personal Preparation

Generally, effective preparation for teaching AP Statistics consists of a four-part strategy. The first step is to assess your own knowledge of statistics and make a plan to fill in the gaps. The second part is to acquaint yourself with the information available about how to teach introductory statistics, which includes fascinating research on how students think about and learn probability and statistics. The third element is to begin to collect the material that you will use in the classroom. The final component is to find ways to communicate with and stay connected to other teachers of introductory statistics so that you can keep abreast of new developments in statistics education and share what you have learned. The sections below contain suggestions about how to accomplish all this, from me and other teachers who have been there.

Expand Your Knowledge of Statistics

If you want to learn more about statistics, see if you can take a class at your local university, or two- or four-year college, from a knowledgeable statistician who is also a skilled teacher. Before enrolling, however, check on the content of the course. Make sure that it covers the techniques of modern data analysis and planning studies emphasized in the Topic Outline for the AP Statistics course.

Alternatively, you could read one or more of the many fine books on elementary statistics now in print. Because there are several different philosophies and ways to approach the study of statistics, it is always a good idea to read a textbook other than the one you are using. Experienced teachers might even consider switching textbooks after a few years to gain a different perspective (budget constraints and local or state textbook adoption policies permitting). In addition to books with statistics content, it is helpful to read about the teaching of statistics. Chapter 5 contains a bibliography of suggested professional readings in statistics and teaching statistics.

The American Statistical Association (ASA) offers significant resources relevant to K–12 education in general and AP Statistics in particular (visit www.amstat.org). Schools may join the ASA via K–12 school membership and receive subscriptions to *Chance*, *STATS*, and the *Statistics Teacher Network* newsletter. The ASA has established an "Adopt-a-School" program to promote contact between schools and professional statisticians in industry, government, and academia. In addition, the ASA can provide a list of statisticians who would be happy to come to your school to talk with statistics students or to invite you and your students to visit their place of business.

One of the best ways to learn how to think statistically is to study examples of how great statisticians analyze data. Good examples are readily available and can be found on some of the Web pages already mentioned, as well as in Chatterjee et al., *A Casebook for a First Course in Statistics and Data Analysis*; Peck et al., *Statistics: A Guide to the Unknown*; *Chance* magazine; and the *Statistics: Decisions Through Data* videotapes developed by the Consortium for Mathematics and Its Applications (see chapter 5 for full citations).

Getting Yourself Ready

As you prepare to teach this course, you may find, as I did, that some areas are very familiar and others much less so. Concentrate on your weaker points. If you have forgotten certain topics, take a class if necessary. At least work through your textbook before you teach it. Better yet, go to a one-week AP Summer Institute prior to teaching the course. Seek recommendations from colleagues about which ones they have attended and found useful.

It is equally important to become part of a network of AP Statistics teachers. You don't want to "go it alone." A local group of AP Statistics instructors may already exist; if not, you can create a support group to help each other during the year. Here in North Carolina, we formed the MCSTATS (Mecklenburg County Stats) group, which met once a month and shared information on pacing, activities, tests, and so forth. Experienced teachers can help you get through the first year or two. A local university may also have at least one instructor who is willing to provide some much-appreciated academic insight into content and concepts. Through the work of David Royster, with support from Rich Lambert, we have an AP Statistics evening several times a year at the University of North Carolina–Charlotte. Finally, be sure to join the AP Statistics Electronic Discussion Group (EDG). Even as a "lurker," you will find the messages informative. A searching of the EDG archives will yield many sources of information.

There are incredible options for teaching this course in terms of textbooks, technology, projects, and activities. It may feel overwhelming during your first couple of years. Research as much as you can, with the understanding that there is not one perfect choice. If you have taught another AP course (for example, AP Calculus), know that this is a very different experience. Although that might be initially unnerving, it is also exciting.

—Sheila McGrail, Charlotte Country Day School,
Charlotte, North Carolina

Attend Professional Meetings

It is strongly recommended that you attend an AP Summer Institute during the summer prior to teaching the course for the first time. This four-and-a-half-day workshop is usually led by an experienced AP Statistics teacher and is packed with information, handouts, lesson ideas, and teaching tips. It is not meant to teach you all of the statistics you may need to know for the course but rather how to more effectively teach the course and negotiate the toughest concepts that will confront students. In addition, the College Board sponsors one- and two-day workshops that you can attend in your region. These are not only a great way to keep in contact with other teachers of statistics but also to gather new ideas for your classroom. To find a professional development opportunity in your area, click on the *Institutes and Workshop* link on AP Central or contact your College Board Regional Office (you can find the address and telephone number of your regional office by clicking on the *Contact Us* link at the bottom of any AP Central page).

Many high school introductory statistics courses are taught by mathematics teachers, and the major professional associations in mathematics have begun providing resources and workshop opportunities for their members aspiring to teach statistics. The National Council of Teachers of Mathematics (NCTM), the Mathematical Association of America (MAA), the American Mathematical Association of Two-Year Colleges (AMATYC), and the Consortium for the Advancement of Undergraduate Statistics Education

(CAUSE) have sessions and workshops on teaching statistics at their local, regional, and national meetings. CAUSE also sponsors the United States Conference on Teaching Statistics (USCOTS), which has sessions of direct interest to AP Statistics teachers. The ASA/NCTM Joint Committee sponsors a "Beyond AP Statistics" (BAPS) session at its annual joint statistical meetings. This workshop is offered for AP Statistics teachers and consists of enrichment material beyond the basic AP syllabus. BAPS participants are also provided with a complimentary registration to the meetings so that they can visit the exhibit hall or attend statistics education sessions on the day following the workshop.

Gather Materials

Good statistics teaching is as much an attitude as a set of skills. Statistics, more than any other mathematical discipline, transcends its theoretical base to serve other scientific disciplines. As John Tukey, the legendary statistician, remarked, one of the best things about statistics is that one gets to play in everybody else's backyard. A teacher of statistics is constantly alert to how data may be and are collected and used in all the backyards in the neighborhood. You will find that teaching an AP Statistics course changes the way you look at the world.

Experienced statistics teachers have file folders containing examples they have gathered from newspapers, magazines, television, and electronic and online sources. Begin your own collection. Opinion polls are routinely reported in newspapers, as well as reports about scientific experiments of public and personal interest. Frequently these reports contain references to their sources, many of which are available online with expanded information. Make one file folder for each of the items listed in the AP Statistics Topic Outline. Each time you come across an example in the newspaper, on television, or in a book, or hear a good idea from a colleague, put it in the appropriate folder.

The *Mathematics Teacher*, familiar to all members of the National Council of Teachers of Mathematics, often has articles on teaching statistics. The *American Statistician*, a publication of the American Statistical Association, frequently contains articles accessible to the teacher of introductory statistics, especially in the "Teacher's Corner" section. *STATS* and *Chance* are two other excellent sources of articles. Another very good resource is the *Journal of Statistics Education* (see chapter 5 for full descriptions of these publications). When you find data that might interest your students, place that article in the appropriate file. You should also have a folder for possible student projects and ideas on how to organize such projects. When constructing lessons or problems of interest to your students, your cache of data, newspaper reports, and journal articles will be priceless! A word of warning: your collection of file folders can easily turn into a complete file cabinet as sources are discovered, located, and revisited. Be sure to cull outdated sources and reverify URLs. Also, make it a habit to record the bibliographic information for articles when you cut them out.

Data Sources

Need data? No problem! Students enjoy collecting information about themselves. It's easy, fun, and readily available. Here are some suggestions:

Categorical Data
Elementary school attended
Eye color
Favorite food
Favorite music genre
Favorite subject or class
Greatest fear
Worst-tasting food

Univariate Data
Amount of money in pocket or purse
Height in inches
Number of letters in name
Number of minutes spent talking with parents or guardians in a day
Number of people in family
Number of phone numbers saved in cell phone
Shoe size by gender
Time it takes to get ready for school
Time spent on last night's homework
Time spent on the computer in an average week
Time spent watching television in an average week
Weight of backpack (use the nurse's scale)

Bivariate Data
Height versus shoe size
Height versus "wingspan"
Resting pulse rate versus number of hours spent working out per week
Time on quiz versus grade

—Penny Smeltzer, Westwood High School,
Austin, Texas

Mathematics instructors who teach statistics sometimes feel isolated, in that they are frequently the only one in the department teaching this subject. This isolation can be easily alleviated! Although you may be the only teacher of statistics, you are not the only user of statistics in a high school. You will find that your colleagues in the sciences, social sciences, economics, physical education, and health fields use data in their teaching but very often do not analyze it with any sophistication. Ask them to collect data from their laboratory experiments and have them describe the statistics that students need to know in order to analyze those experiments. Ask to borrow a lab manual so you can see the kind of data that are collected. Teaching is easier when it is collaborative!

Get Connected to the AP Statistics Community

AP Central, the Source of All Things AP Statistical

As part of its mission and focus on professional development for AP teachers, the College Board has developed an official online home. AP Central (apcentral.collegeboard.com) is a free Web site for all those involved in or interested in the AP Program, including new and experienced teachers, AP Coordinators, counselors, college faculty, and school and college administrators. The goals of AP Central are to inform, support, and connect the AP community. AP teachers face two significant challenges: first, keeping up-to-date in their discipline and with the AP Program; and second, finding appropriate and sufficient resources to enhance and support their teaching. Teachers will have a better sense of involvement in the AP Program through both the information at the site and the opportunities to contribute.

AP Central offers a unique and growing set of resources. Here you will find the most recent information on the AP Program, including official Course Descriptions, information on the exams, sample syllabi, teaching resources, publications, frequently asked questions (FAQs), and more. You can personalize your online experience in the *My AP Central* section to access facts about AP Statistics and other courses of your choice, in addition to choosing information specific to your location.

The content area of AP Central for this course is the AP Statistics Course Home Page, a site with links to hundreds of print and electronic resources. Here teachers will find tips contributed by colleagues in the AP Statistics community, activities to support teaching AP Statistics, links to useful Web sites (including professional associations), and other relevant information submitted by AP professionals.

An important component of the Web site is the *Teachers' Resources* section (click on the link on the AP Statistics Course Home Page), an online application designed to give AP teachers a free, quick, and efficient way to search for resources that they can use to create lessons and activities for their classes or to improve their own understanding of a subject. The inventory of annotated references includes resources of all kinds—textbooks, reference books, documents, Web sites, software, calculators, videos, and more—with information on their origins, location, content, and quality. All of the resources have been reviewed by college or high school faculty and contain assessments of their value in teaching a successful AP course. Users of this database can add their own comments on each resource and contribute to a discussion of its usefulness.

Clicking on the *Institutes and Workshops* link at the left of the AP Central screen takes you to a searchable database featuring information about training events offered through the College Board and other educational organizations and professional associations. Participating in an AP workshop for professional development is generally one of the first steps to becoming a successful AP teacher. These workshops offer intensive subject-specific training on the content and methods of teaching AP courses and serve as a forum for exchanging ideas, materials, activities, and helpful pedagogical strategies.

Other features on AP Central include:

- Information on the AP Course Audit and AP Statistics Curricular Requirements.
- The latest *AP Statistics Course Description*, which may be downloaded as a free PDF.
- Course overviews and exam tips written by current AP Statistics teachers.
- Official policies on calculator use.
- Feature articles written by both secondary- and college-level professionals, as well as profiles of stellar AP teachers and AP schools.
- The *Teaching Resource Materials* and *Teaching Resource Reviews* sections on the Statistics Course Home Page include articles written by teachers in the field. For example, one outstanding resource in this list is the "AP Statistics Web Guide" by Ruth Carver and Susan Peters. This excellent compilation is organized by the AP Topic Outline, with linkable interactive Web sites, lesson plans, and activities developed by statistics teachers.
- A monthly update about important AP developments and events.
- Information about professional opportunities in AP, including becoming a workshop faculty consultant or a Reader for the AP Exam.
- Weekly AP news stories.

- Free-response questions and scoring guidelines for past AP Exams, as well as a complete Practice Exam available as a free download to teachers whose syllabi have been approved in the Course Audit process.
- A link to the College Board Store, which features a variety of print materials, including Released Exams and specialized modules for particular units of study, such as sampling and experimentation.

Electronic Discussion Group (EDG)

Many teachers of AP Statistics are of the opinion that the AP Statistics Electronic Discussion Group (the EDG, also informally known as "the AP Stat listserv") is the best resource available to new (as well as experienced) teachers. The EDG is a lively, friendly, and helpful Web-based discussion group consisting of teachers of AP Statistics and college and university statistics professors who give their time and expertise to the AP Statistics community. Many of the authors of commonly used textbooks are members and frequent contributors. New teachers have expressed their appreciation for such a supportive forum in which to learn about AP Statistics. Besides addressing questions about the course content, it is an excellent resource for teaching tips, activities, and help using technology—both computer and calculator. The EDG has been a resource for teachers of AP Statistics for years, and the archives of these discussions are available at http://mathforum.org/kb/forum.jspa?forumID=67. You can sign up by clicking on the EDG link on the AP Statistics Course Home Page.

Frequently Asked Questions About Statistical Concepts for New Teachers

A list of frequently asked questions from the EDG is maintained at "AP Statistics FAQ" (www.mrderksen.com/faq.htm), just one of many sections on Jared Derksen's helpful Web site. It is the place to start when you have questions such as: "What is the difference between using *n* versus using *n*-1?" "How do I explain confounding and blocking?" "How do I explain the meaning of *r*-squared?" "Are there any good review books?" "What can I do after the AP Exam is over?" Click on "Top 10!!!," which includes the most frequently asked questions. This site has cataloged excellent responses from some of the best in our field to these and other vexing questions. You can sometimes save time by checking the available FAQs before posting a question of your own.

At this same FAQ site you can find a link for *New AP Statistics Teachers*. Here you will find general information, a list of recommended textbooks, technology resources, links to experienced teacher Web sites, and much more. (See also Jared's syllabus, later in this Teacher's Guide.)

Experienced Teacher Web Sites

One of your greatest resources after AP Central will be the Web sites of experienced teachers such as Jared Derksen. Some of these sites can be accessed through his Web page, as discussed above. These colleagues have assembled lots of links to successful activities, excellent data sets, applets, projects, and other resources, which will save you a substantial amount of searching and trial and error. If you happen to click on one of the links, say *projects*, and it takes you to the Statistics EDG, simply type "projects" into the search dialog box, and it will take you to the appropriate responses in the archives.

It is possible to be overwhelmed by the avalanche of available resources. You might start with only one or two of the experienced teacher Web sites, choosing, for example, Al Coons, Jared Derksen, Jason Molesky, or Sheila McGrail. Their Web addresses are listed in chapter 5 of this Teacher's Guide. As you begin to get the course under your belt, work outward from your initial choices to the remaining very useful sites offered by the rest of the teachers listed in Jared's index. Each has a lot to offer in the way of interesting activities, teaching suggestions, handouts, old tests, and so forth. Many have posted a syllabus online.

Models for Statistical Analysis

We have discussed the logistics of the course, your own intellectual preparation, and the support available to you—but as useful as all that information is, you may still be wondering how the AP Statistics curriculum actually plays out in the classroom. To give you some flavor of the course, three data sets are analyzed below:

- Stroop effect (an experiment with two independent populations)
- Size of alligators (regression with nonlinear data)
- Plantar fasciitis experiment results

These analyses are in the spirit of, but perhaps a bit more extensive than, a type of investigative task that will appear on the AP Statistics Exam. They are included here to give you an idea of what you might expect an able student or group of students to do with a data set if they are given the time to do their best work. Notes and commentary are included along the way to help guide you in areas where students tend to have difficulty or neglect to be as thorough as needed.

For these examples a variety of approaches are included to show the kinds of analyses that are appropriate in a variety of settings. The data sets have been chosen so that the analyses illustrate many, but not all, of the methods encompassed in the AP Statistics course. All of the following analyses can easily be done with a graphing calculator, although they might be more easily accomplished with the aid of a computer.

In each of the following, a statistician has analyzed a set of data using the exploratory and inferential techniques incorporated in the AP Statistics course. Sometimes there is more than one useful way that a particular set of data can be analyzed, and different statisticians may well have approached the same data with other, perfectly valid, techniques. A data set like this one can be presented early in the course to introduce one idea (study design or comparing data sets) and then used again later to demonstrate other ideas (inference). A good example of this approach can be found at the North Carolina School of Mathematics Web site (http://courses.ncssm.edu/math/Stat_Inst/links_to_all_stats_institutes.htm) under the 2007 Statistical Institute. The activity is called “Seeing Red.”

Analysis 1. Stroop Effect

The original study that led to the interference phenomenon discussed here was first published in 1935 by J. Ridley Stroop.[6] C. James Goodwin refers to this study as possibly the most widely replicated study in psychology.[7] The phenomenon is widely known among psychologists as the Stroop effect, and variations of the original experiments are still published today in the psychological literature.

In the history of experimental psychology related to cognitive processes and learning, the concept of interference has been very important in the literature. Studying the associations and habits that either facilitate or inhibit cognitive behavior helps psychologists understand how learning can be improved. One such study involved the presentation of colors (red, green, brown, blue, and purple) to college psychology students. Students were randomly assigned to two groups and given a “name the color of the word” test. Subjects in the first group were presented with colors in the form of a written word, and their task was to name the *color* of the word as quickly as possible. For example, the word *red* would be printed in red,

6. J. R. Stroop, “Studies of Interference in Serial Verbal Reactions,” *Journal of Experimental Psychology* 18 (1935): 643-62.

7. C. James Goodwin, *Research in Psychology: Methods and Design*, 2nd ed. (New York: Wiley, 1998), 212.

and the correct response was "red." The other group was also presented with colors, but the printed words did not match the color of the word. For example, the word *red* might be printed in blue, the word *brown* printed in green, and so on. The task of the subjects in this second group was also to name the *color* of the word, ignoring the word itself. That is, if the word *green* was printed in blue, the subject should correctly respond with "blue."

The experiment was designed to investigate the theory that reading is so automatic in adults that the subjects' reading would interfere with the correct identification of the color. If this theory of interference is correct, the subjects presented with the colors matching the words should correctly identify the color of the word faster. The data from this experiment are reproduced below. Each student in both of the experimental groups was presented with 100 words. For each word, the student continued to respond until the correct color was identified and then moved on to the next word. The total time in seconds to name the color of all 100 words is recorded for each student. Times have been rounded to the nearest second.

Times for the Two Experimental Groups

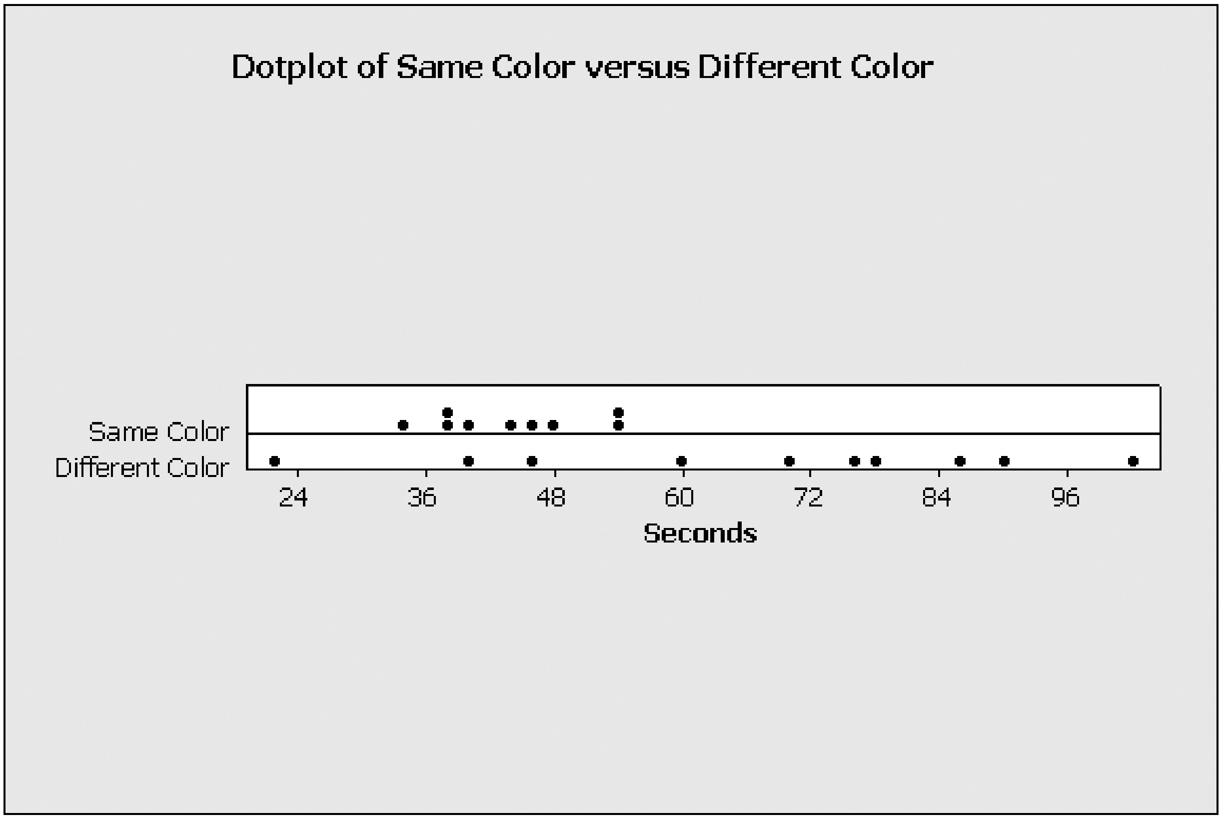
Different color	Same color
40	37
45	33
90	45
69	43
75	53
59	37
102	47
78	53
21	40
86	

An initial look at graphical displays of these data suggests that the reading is consistent with the theory of interference with the identification of the colors.

Times with Different Colors		Times with Same Color
1	02	
	03	377
50	04	0357
9	05	33
9	06	
85	07	
6	08	
0	09	
2	10	

Key: 3|2 represents 32 seconds

The above back-to-back stemplot shows that the time measurements produced from the presentation where the colors matched the words were consistently smaller than when the colors and words did not match. The median time for correctly identifying 100 colors when the color matched the word (43 seconds) was lower than the median time for correctly identifying 100 colors when the color was different from the word (72 seconds). It also appears that the response times produced from the dissonant colors and words were much more variable than those produced with the same color, as the range for the same color (20 seconds) was much smaller than the range for the dissonant color or word combinations (81 seconds). Both distributions of times were relatively symmetric. This is also apparent from the parallel dotplots below. *Either of the two graphical displays would be an acceptable way to present the data.*



These conclusions are supported by the summary statistics.

Summary Statistics for Time Measures

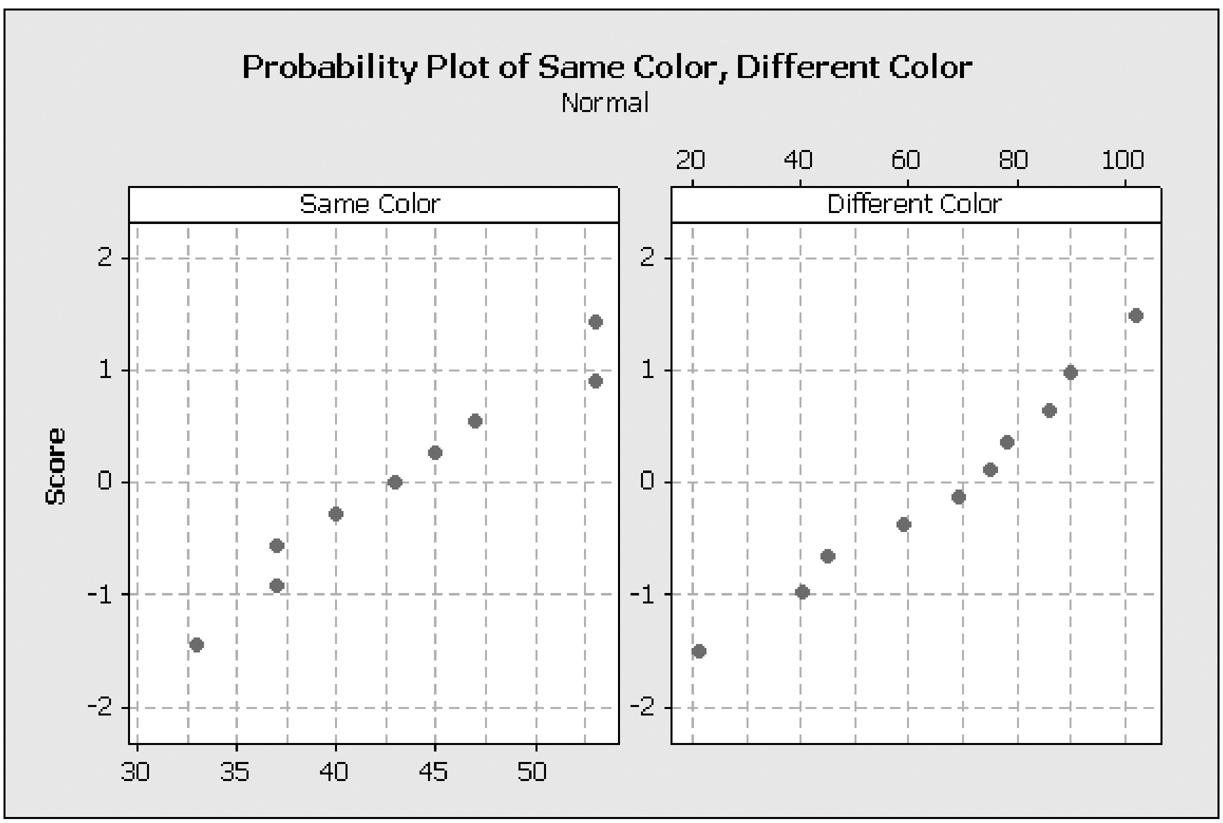
Same color	Different color
Mean = 43.1 seconds	Mean = 66.5 seconds
Median = 43 seconds	Median = 72 seconds
$n = 9$	$n = 10$
Std dev = 7.08 seconds	Std dev = 25.15 seconds

One might be tempted to conclude that the mean times for these groups are significantly different by just examining the previous dotplots or stemplots. The two distributions do indeed look different, but could these differences have occurred by random chance? To determine whether the observed difference between the mean time when the color and the word match and the mean time when the color and word are different is statistically significant, a two-sample *t* test could be considered. *Students tend to throw around the word significant with indiscriminant abandon. Caution them that they must use statistical terms correctly and in context.*

Because the graphical displays lead us to suspect a difference, another option would be to estimate the magnitude of the difference in the two means via a confidence interval based on the *t* distribution. We must first check the conditions necessary for the confidence interval procedures to be valid. *It is important that students check all relevant conditions before conducting any inference procedure. Do the conditions exist that justify our choice of a particular inference procedure? A good discussion of assumptions versus conditions can be found in an article by Dave Bock on the AP Statistics Home Page under* Teaching Resource Materials: "*Is That an Assumption or a Condition?*"

What conditions must be verified to construct a confidence interval to estimate the difference in two means?

- Independent samples are randomly drawn from two distinct populations, or the two groups are generated by a random allocation mechanism.
  Check: Recall that the subjects in the experiment were randomly assigned to the two treatments, creating two independent groups.
- In general, the underlying populations should be normally distributed. This matters most for small samples. If *n* is small, say less than 30, the observed data should not show extreme skewness, and there should not be any outliers.
  Check: The dotplots constructed previously do not suggest asymmetry in either underlying population, and there do not appear to be any outliers present. (One could look at the stemplots as well.)
  An alternative approach is to construct a normal probability plot for each treatment. This plot graphs each data value against its corresponding *z*-score in the distribution. These are not easy to do by hand, so it is expected that students will use their calculators to construct the plots.
  If the distributions of the data are approximately normal, the resulting plot will be roughly linear. We can see in the plots below that this appears to be the case for the Stroop data.



Thus, it appears that the *t* procedure for two independent samples is appropriate.

Let μ_S = the population mean time for correctly naming the color in 100 repetitions when the color and the word of the color were the same, and μ_D = the population mean time for correctly naming the color in 100 repetitions when the color and the word of the color were different. *Always identify any symbols used in the procedure.*

The parameter of interest is the difference in mean times for the two populations, that is, $\mu_D - \mu_S$. A two-sample *t* interval for independent means will be constructed. The appropriate formula would be:

$$(\bar{x}_d - \bar{x}_s) \pm t^* \sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}$$

The 95 percent confidence interval for estimating the difference in the two population means (different minus same color treatments) is: $5.03 < \mu_D - \mu_S < 41.74$ with df = 10.56. Most students will likely do their work for this type of problem using the statistical test on their calculator and read the above df value from the calculator, whereas others will do their work by hand and use the degrees of freedom based on 1 minus the smaller sample size minus 1 (df = 8). This latter value is a bit conservative in that it tends to produce an interval with slightly higher than desired coverage probability. (Note that the interval was obtained by using the nonpooled option on the calculator, which is valid whether or not the population variances are equal. The pooled option is a special version of the two-sample *t* statistic that assumes the two populations have the same variance. The best advice for comparing two means is, don't!)

We are 95 percent confident that the interval from 5.03 to 41.74 seconds captures the true difference in mean times to correctly identify the color of the word in 100 repetitions. *The construction of a confidence interval should always have an accompanying interpretation of the resulting values.*

Notice that zero lies outside the confidence interval. From this we conclude that the difference in the mean times produced from presenting the colors with the "correct" verbal description and the mean times produced from presenting the colors with the "incorrect" verbal description differ significantly. In fact, the 95 percent confidence interval gives us a set of plausible values for those differences. *If zero had been in the interval, it is plausible that there is no meaningful difference between the two populations. There would be insufficient evidence to conclude that a difference actually existed. It is important for students to understand that failure to conclude a difference exists is NOT confirmation that the two groups are the same!*

In summary, it seems that the investigators were correct in their conjecture that the dissonant word/color treatment produces times that tend to be greater than those produced by the consistent word/color treatment. The subjects were college psychology students, and they were randomly assigned to the two treatments. Thus, it appears that for the psychology students who participated in this experiment, the differences in the times are reliably different. If the college psychology students can be regarded as a random sample from the adult population—a proposition that is by no means obvious—it may be that these results would generalize to the adult population.

Class Activity: Conducting the Stroop Experiment

If you do an Internet search for "Stroop effect," several useful Web sites appear, some of which allow you to actually gather some data for class. One of the best is at http://faculty.washington.edu/chudler/words.html. By clicking on the timer you can keep track of the length of time it takes to conduct each part of the above experiment. Have students record the times and bring them to class. Variations also exist, such as animals (same name as animal pictured /different name), numbers, and shapes.

You can conduct analyses using times for males and females correctly naming the same color, and then males and females correctly naming the different color, or even students' comparisons of themselves reading the same and different colors (matched pairing).

Analysis 2. Size of Alligators

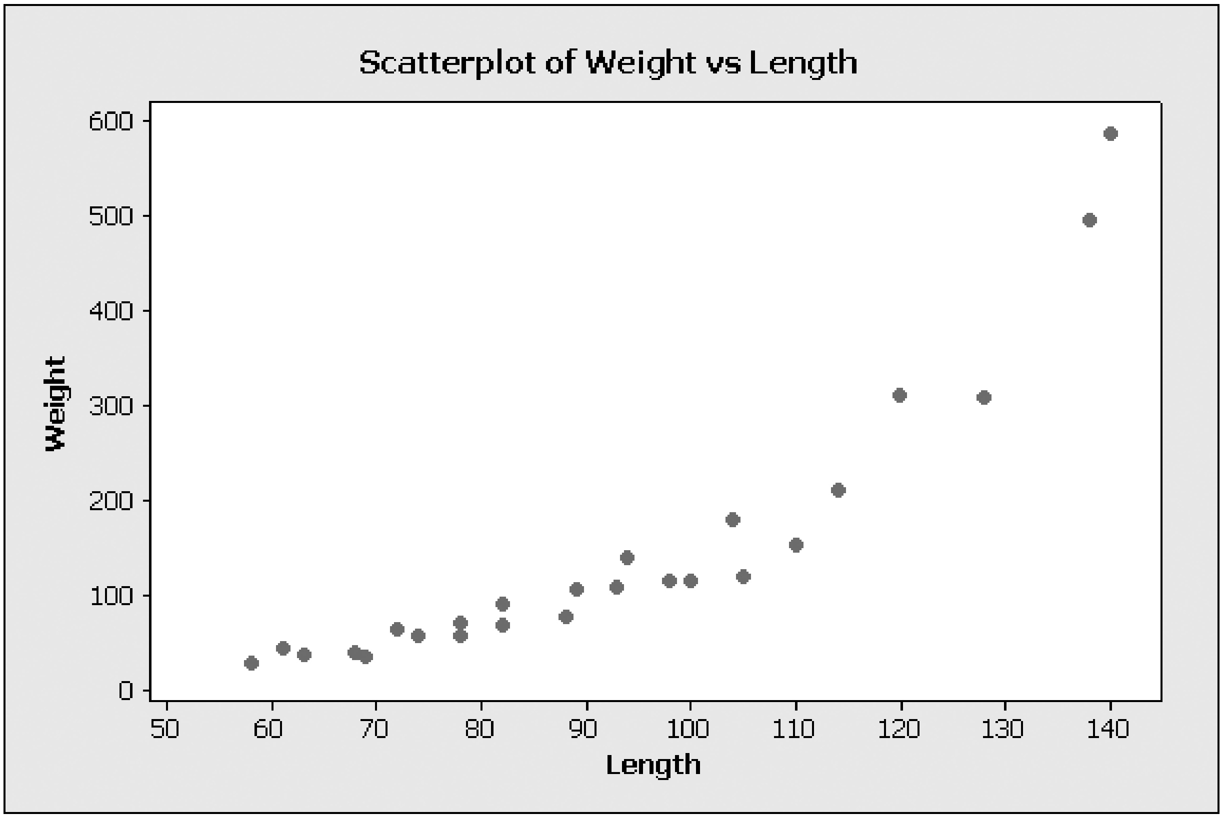
Biologists who take aerial photographs of wildlife habitats often monitor many wildlife populations. Information about the number of animals and their whereabouts is important data for organizations seeking to protect certain species and to ensure the safety of surrounding human populations. This has become more important as housing developments continually encroach on animal habitats, bringing humans and animals in more direct contact. In addition, it is sometimes possible to monitor certain characteristics of the animals. The length of an alligator can be estimated quite accurately from aerial photographs and from visual sightings from air or boat. However, the alligator's weight is much more difficult to determine. In the following example, data on the length (in inches) and weight (in pounds) of a sample of alligators captured in central Florida are used to develop a model from which the weight of an alligator can be predicted from its length.

(Note: This activity appeared in the 2002 *AP Statistics Teacher's Guide*, but the data have been updated for this publication.)

Characteristics of Alligators
(Central Florida Sample)

Length (inches)	Weight (pounds)	Length (inches)	Weight (pounds)
104	181	110	153
100	115	88	78
140	587	82	68
58	28	74	57
120	311	61	44
94	141	138	496
63	37	89	106
105	119	68	39
69	36	78	71
72	65	114	211
128	310	93	109
98	115	78	57
82	91		

An examination of the scatterplot of weight against length reveals that the relationship between these variables is not a simple linear one but rather curved. A successful model must take into account this nonlinear relationship. We further note that there are two particularly large alligators that in the scatterplot appear to be somewhat separated from the bulk of the data. There does not appear to be any reason to suspect these more extreme observations are the result of a measurement or other type of error, although this should always be considered when there are outliers present.



As a starting point, let's consider a linear model. The *Minitab* output below represents the fitting of a simple linear model to the data.

The regression equation is
Weight = -358 + 5.45 Length

Predictor	Coef	SE Coef	T	P
Constant	–358.16	52.77	–6.79	0.000
Length	5.4549	0.5552	9.82	0.000

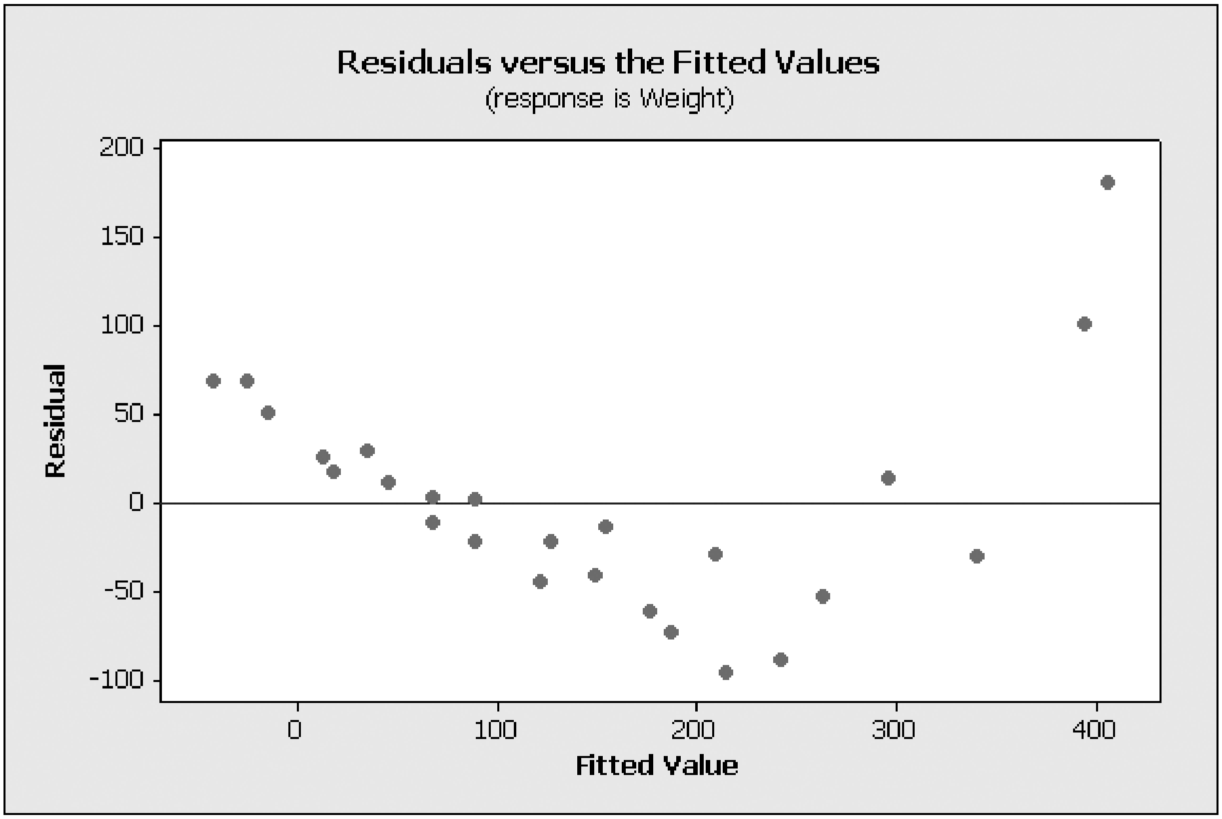
S = 63.6182 R-Sq = 80.8 percent R-Sq (adj) = 79.9 percent

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	390653	390653	96.52	0.000
Residual error	23	93087	4047		
Total	24	483740			

There is more information in the computer output than an AP student is responsible for knowing. It is important for a student to be able to sift through the output and find the relevant numerical values.

An examination of the residual plot (below) shows that there is a pattern in the residuals. Such a curved pattern indicates that a linear model is not likely to be the best fit for these data.

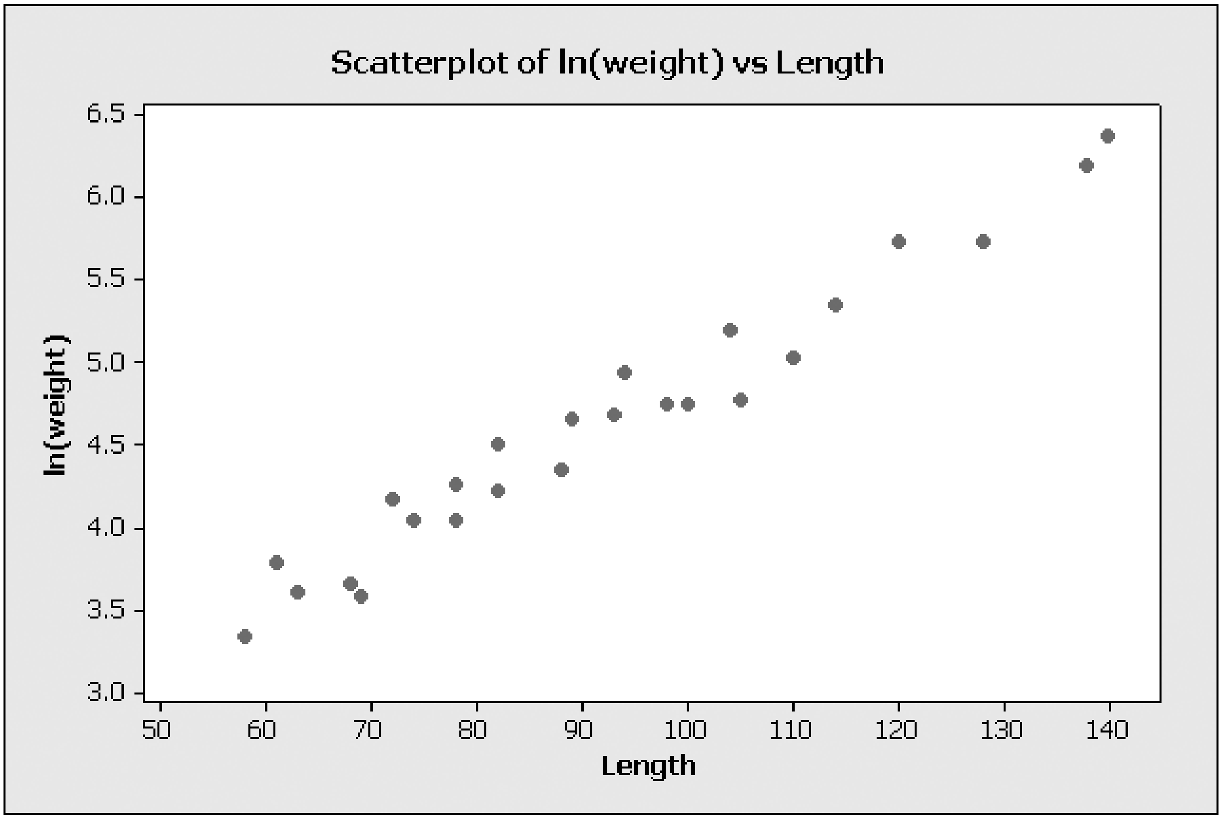


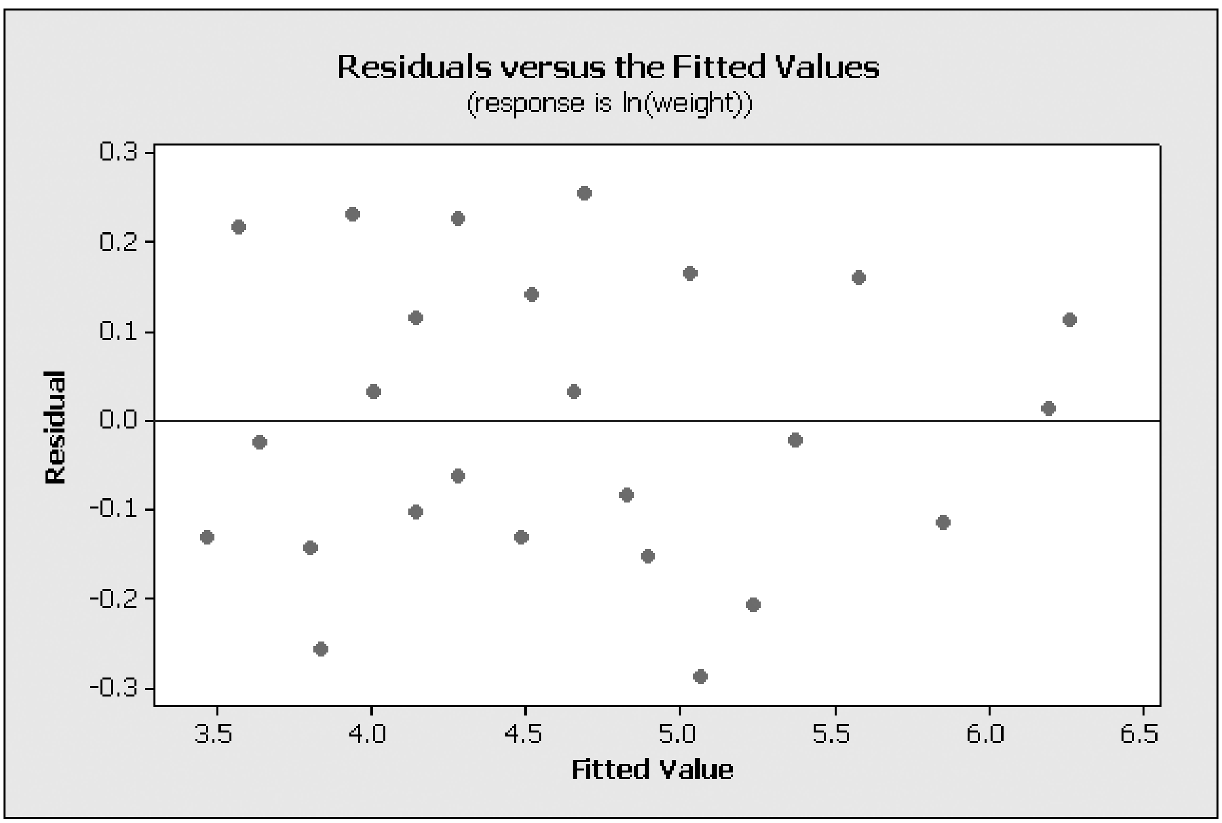
There are many possible transformations that might improve the model, and most textbooks give strategies for making a good choice. In this example, we will concentrate on the use of logarithms to straighten the data. *This is something that is particularly helpful to my students, since straightening data is something they do in physics, when they gather data for motion down an incline.*

The scope of the AP Statistics course limits itself to the linearization of data. The course does not address fitting quadratic, cubic, quartic, or logistic models to data. You might consider looking at these during any postexam time you have.

There are several reasonable methods we might try to straighten the data—taking the log of the response variable, taking the log of the explanatory variable, or taking the log of both variables. It sometimes takes a bit of trial and error to come up with a best-fitting model. This process involves "taking the log of" a variable (we could use either common or natural logs) and examining the resulting scatterplot for linearity and the residual plot for no pattern.

After some trial and error, we will take the natural log of the response variable, weight. An examination of the resulting scatterplot for the transformed data indicates a more linear relationship between length and ln(weight).





The residual plot above indicates that this model is a better fit. There does not appear to be a readily apparent pattern in these residuals, as there was in the residual plot for the original model.

Important Notes

1. The residual plots in computer output often differ from those that are normally created on the calculator. Computer software is likely to plot the residuals against the fitted (predicted) values from the model, whereas most calculators will plot the residuals against the original or transformed x-values. The reason for this difference is that the computer software assumes a multivariable analysis is being carried out, whereas the calculator assumes a simple linear regression. In a simple linear regression, calculator plots of the residual versus x and the residual versus y-hat give the student equivalent information; this is not so in a multiple regression. Be sure to point this out to students.

2. On the AP Exam, it is not expected that students will be doing as much calculator-intensive transformation work as this problem implies. A more typical scenario might present a problem situation with one or more possible models to fit the data and accompanying computer output and plots. Students would be expected to work with the given models to answer questions. It would not be unusual if they were asked to decide which model is the most appropriate to use to answer the question and then to justify their choice of model.

3. Most current textbooks include a fair amount of computer output. Students should be able to read and interpret a variety of output from different software packages. Make sure they are exposed to such during the year.

After the transformation, the *Minitab* regression for the alligator problem is given below.

The regression equation is
ln(weight) = 1.49 + 0.0341 Length

Predictor	Coef	SE Coef	T	P
Constant	1.4854	0.1369	10.85	0.000
Length	0.034111	0.001441	23.68	0.000

S = 0.165087 R-Sq = 96.1 percent R-Sq (adj) = 95.9 percent

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	15.276	15.276	560.51	0.000
Residual Error	23	0.627	0.027		
Total	24	15.903			

If we choose to adopt this model using ln(weight) and length, we would test hypotheses and construct confidence intervals using the transformed model. However, we are more likely to use the model to predict the weight of an alligator based on its length. It is important to note that students do not need to back-transform the model; however, they will be expected to be able to back-transform any predictions into the original scale.

For example, using the transformed model of $\ln(weight) = 1.49 + 0.341(length)$, predict the weight of an alligator that is 90 inches in length.

$$\ln(\widehat{weight}) = 1.49 + 0.0341(90)$$
$$\ln(\widehat{weight}) = 4.559$$
$$\widehat{weight} = e^{4.559}$$
$$\widehat{weight} = 95.49\,pounds$$

The model suggests that we can predict that an alligator measuring 90 inches in length will weigh approximately 95.5 pounds.

A word of caution is in order. Once you have a good linear model, it is tempting to apply it to all possible values of x. Although a linear model can often do a reasonable job of summarizing a relationship over a given range of x-values, it should not be applied to values outside the data range used to generate the model, because the model may not hold beyond the given values. Extrapolating too far from the data can lead to errors in predictions.

Analysis 3. Plantar Fasciitis Experiment Results

Plantar fasciitis is caused by the tearing of the plantar fascia, a ropelike band of fibrous tissues that runs from the heel to the toes and supports the arch. The tearing tends to be caused by standing, working, or exercising on hard surfaces (concrete and asphalt, in particular). This condition chronically afflicts teachers, nurses, and athletes of all types. Even mild activity such as walking or jogging can lead to a bout of plantar fasciitis, a nagging injury that may take six to nine months to heal. For about 10 percent of sufferers, recovery may take even longer.

In the past, a common exercise for this injury was the Achilles tendon stretch, which involves a series of exercises that stretch the calf muscles. A team of medical researchers was interested in studying whether a new exercise designed to stretch the plantar fascia might be more effective than the currently recommended exercise in speeding recovery from this injury. The new stretch involves holding the toes and curling them backward toward the shin, while flexing the ankle. Researchers recommended that the new procedure be done immediately after the sufferers have gotten out of bed and after other periods of inactivity.

A 12-week trial comparing the new plantar fascia stretch to the Achilles stretch is to be performed using 120 randomly selected patients who are suffering from plantar fasciitis but have never tried the Achilles stretch. They would be taught the proper techniques for either the Achilles stretch or the plantar fascia stretch. At the beginning and end of the study, the researchers will measure the patient’s mobility in the foot afflicted with the plantar fasciitis. The researchers believe that the new treatment will be more effective; that is, that the proportion of plantar fasciitis sufferers in the plantar stretch group who have improved mobility in their foot at the end of the 12-week period will be higher than the proportion for the Achilles stretch group.

Let’s first focus on the experimental design aspects of this study.

How should the subjects be randomized to the treatment groups?

There are many methods of accomplishing the random assignment of the patients. For example, randomly select a patient and flip a coin. If the coin is heads, assign the sufferer to the Achilles stretch group. If it is tails, assign the patient to the plantar fascia stretch group. *This method will almost surely not yield equal sample sizes.*

If equal sample sizes are desired, the following method will result in a completely randomized design. Assign each patient a unique random number from 001 to 120, using a random number generator on a calculator, statistical software, or a random number table. The numbers will then be sorted from smallest to largest. The patients with the first 60 numbers in the ordered list will be assigned to the Achilles stretch. The remaining 60 will be assigned to the plantar fascia stretch.

Students should be able to discuss assigning subjects by various randomization methods: a random number table, drawing numbers or names from a hat, or flipping a number cube or coin, for example. The important feature is that the chance of being assigned to each treatment group is the same for each participant.

Why is randomization important in this experiment? Why not just let the subjects choose to which group they will belong? Without random assignment of the plantar fasciitis patients to the two exercises, it is possible that the two treatment groups could differ in some way that affects the outcome of the experiment. For example, suppose the patients in one of the treatment groups knew each other and shared a similar work environment. Their company decides to install carpeting throughout the workplace, replacing the hard surfaces that had previously existed. If all these workers were in the same treatment group, the researchers would not know if the reduction in reported pain is attributable to the treatment or to the carpet installation. Any observed difference in the results for the two exercise groups would be confounded with the effects of installing the carpet. Randomization is insurance against any such pattern, whether we are aware of it or not.

The control group for comparison purposes in this experiment is the standard treatment of the Achilles stretch. Should there be an *additional* do-nothing (placebo) group? The addition of such a placebo group would enable researchers to determine if either type of exercise had more benefit than no exercise. No placebo group is necessary for this experiment. The objective is only to determine whether the new treatment is better than the current one. The burden of proving "efficacy" is common in medical trials, and to gain approval one must always show that the proposed new treatment is better than the standard one.

Is blinding possible in this experiment? It is not possible to blind the participants, as they are being directed to perform one of the stretches. The evaluators of the results should not know which participant was assigned to which treatment group, so that their conclusions are not biased in favor of one of the treatments.

To what population might any results be generalized? Suppose we found that the plantar fascia stretch was more effective than the Achilles stretch. If we truly have a random sample of all plantar fasciitis sufferers, then the results of this experiment could be generalized to that group. If, on the other hand, the random sample came from athletes, then the results of this experiment do not directly apply to nurses or teachers, for example, because they were not part of the experiment.

What inference procedures can be conducted?

Researchers often wish to examine the difference between populations with regard to the proportion falling into a particular response category. Typically, observational studies draw independent random samples from two distinct populations, e.g., males *versus* females, or smokers *versus* nonsmokers. On the other hand, if we were to sample husbands *versus* wives, there is little reason to believe that whatever we might measure about these two populations is unrelated. In experiments, the process of random allocation yields the two groups. In the plantar fasciitis example, the "populations" are the hypothetical populations of those who could have been given the treatment; they are represented by the two treatment groups generated by the randomized comparative experiment. Can it be concluded that the new stretching procedure was better at increasing mobility in sufferers of plantar fasciitis, or could any difference in the two groups be attributed to the natural variation that exists among sample statistics? This question calls for a hypothesis test.

The parameter of interest in our study is the true difference in the proportions of plantar fasciitis patients in the two treatment groups who had increased mobility in the foot.

Let p_1 = proportion of plantar fasciitis patients who would experience increased mobility using the plantar fascia stretch procedure.

Let p_2 = proportion of plantar fasciitis patients who would experience increased mobility using the Achilles stretch procedure.

The null hypothesis is a hypothesis of equality: that is, there is no difference in the proportions for the two populations. The alternative hypothesis is that a difference does exist. In this case, a directional hypothesis is needed: we anticipate that the proportion of plantar fasciitis patients who experienced increased mobility is <u>*higher*</u> *for the plantar fascia stretch procedure.*

$H_o : p_1 = p_2$
$H_a : p_1 > p_2$

Based on researcher measurements of mobility, the data showed that 52 of the 60 subjects assigned to the plantar fascia group experienced an increase in mobility, while 44 of the 60 in the Achilles group experienced an increase in mobility. Because we want to know if a difference exists, we will consider a two-proportion z test.

Are the necessary conditions satisfied to conduct this procedure?

- Independent samples are randomly drawn from two populations or are generated by a random comparative experiment.
  <u>Condition check</u>: While we are told that the patients were randomly selected, the key element in an experiment is that some randomization process is used to create the two independent treatment groups. In this case, we are told that subjects were randomly assigned to either the Achilles stretch group or the plantar fascia stretch group.
- If the data are sampled without replacement, the sample should not exceed 10 percent of the population.
  <u>Condition check</u>: We do not know the size of the population of plantar fasciitis sufferers from which the sample was drawn. However, our inference would be valid if that population size were to exceed 1,200, which is a reasonable assumption.
- Both groups are big enough that at least 5 successes and 5 failures are observed in each.
  <u>Condition check</u>: In the plantar fascia stretch group there were 52 successes and 8 failures, and in the Achilles stretch group there were 44 successes and 16 failures.
  Different books use slightly different conditions—some use 10 or 15 instead of 5. What is important is that the student checks <u>*some*</u> *value.*

The sample statistic $\hat{p}_1 - \hat{p}_2$ (the difference between the sample proportions) estimates the parameter $p_1 - p_2$ (the difference between the population proportions). To find the standard error, we assume that the null hypothesis is true so that $p_1 = p_2 = p_c$, the combined estimate of the common population proportion, and calculate $\hat{p}_c = \dfrac{success_1 + success_2}{n_1 + n_2}$.

For this problem, $\hat{p}_c = \dfrac{52 + 44}{60 + 60} = \dfrac{96}{120} = 0.80$

The test statistic is

$$z = \frac{\hat{p}_1 - \hat{p}_2 - (p_1 - p_2)}{\sqrt{\dfrac{\hat{p}_c(1-\hat{p}_c)}{n_1} + \dfrac{\hat{p}_c(1-\hat{p}_c)}{n_2}}} = \frac{.867 - .733 - (0)}{\sqrt{\dfrac{.8(1-.8)}{60} + \dfrac{.8(1-.8)}{60}}} = 1.835$$

How rare is this value? Could a difference this large have happened by random chance? What is the probability of getting a value at least as extreme as $z = 1.835$ if there really is no difference between the two treatments (that is, the null hypothesis is true)? This is called the *P-value*.

For this situation, the *P-value* $= p(z > 1.835) = 0.0333$. If there really was no difference between the proportion of subjects in the Achilles stretch group and the proportion of subjects in the plantar fascia stretch group who experienced increased mobility, we would have observed a difference at least this large only about 3 percent of the time. If our decision rule were to reject the null hypothesis if the difference could have occurred by random chance less than 5 percent of the time (that is, the Type I error is .05), we would state that there is enough evidence to conclude that the plantar fascia stretch was effective in significantly increasing mobility. If we had set a criterion to reject if the difference could have occurred by chance less than 1 percent of the time, we would have failed to reject the null hypothesis. In this instance we would not conclude that the plantar fascia stretch was effective in significantly increasing mobility.

Suppose the question was, "How much actual difference is there between the proportions of plantar fasciitis patients in the two treatment groups who experienced increased mobility; that is, what is the gap between the two population proportions?" We could estimate that difference with a confidence interval. A 98 percent confidence interval for estimating the difference in the above experiment is given by (–0.034, 0.301). *Note that while 0 lies within the interval, there are other plausible values for the difference in population proportions in addition to zero.*

Caution: Failing to reject the null hypothesis does not mean that the two stretch methods are the same. We are just unable to conclude that a difference exists. To many students, this is confusing. Hypothesis procedures are used to assess the evidence against the null hypothesis, not to assess the evidence in support of it. Failure to find evidence against the null hypothesis does not prove the null hypothesis to be true.

You will also need to help students understand how to write their conclusions. They seem to have more trouble stating a conclusion when they fail to reject a null hypothesis. In the nonrejection case, students should avoid phrases such as "accept the null" or "retain the null" when writing their conclusion. Examine past AP Exam problems and browse several textbooks to see various ways that correct conclusions can be written.

Some textbooks have analogized conducting a hypothesis test to a jury trial. Finding a defendant "not guilty" does not necessarily mean that the defendant is innocent. The evidence just was not strong enough to get a conviction. Using the jury analogy in class can be very beneficial as an introduction to the idea of a significance test. This analogy can also be used to illustrate Type I and Type II errors, the consequences of such errors, power, and even the initial assumption that the null hypothesis is true (presumption of innocence).

Now that we've looked at how to start up your AP Statistics course, and how to prepare to teach this challenging subject, let's turn to the question of developing a syllabus. In the next chapter I'll give some tips on course organization, and eight experienced statistics instructors will share their syllabi and offer suggestions for teaching strategies, grading policies, helpful resources, and student activities that you might consider for your own classroom.

Chapter 3
Course Organization

Syllabus Development

No single AP Statistics course would be appropriate for all students and all learning environments. Some teachers will have well-prepared, engaged, highly motivated students; a new textbook; and lots of resources, including a computer lab. In other years and other schools, the situation may be a bit less rosy. That is why this chapter aims to teach by example. One of the best ways to approach creating your own syllabus is to see what other instructors have done in a wide range of circumstances. That is the purpose of the eight sample syllabi presented in this chapter. In the meantime, some general guidelines to help you in the creation and refinement of your own course syllabus are presented below.

Setting Expectations

This is a college-level course with demanding content. Students should be prepared from the outset to work hard so that there are no surprises down the road. They need to be dedicated and to work conscientiously outside of class. I tell my students to expect a minimum of 30 to 40 minutes of homework each night. In addition to daily class work, they are responsible for the "AP problem sets" that I have assembled (which consist of two to three previous AP Exam questions to be completed and turned in each week), as well as several long-term projects.

Course Planner

When developing your syllabus, you should read the *AP Statistics Course Description* carefully. Keep it, as well as your textbook, close at hand while you are planning. It's also important to make sure the syllabus meets the AP Statistics Curricular Requirements: go to apcentral.collegeboard.com/courseaudit for information on submitting your syllabus for audit review.

Once you have read the Topic Outline in the Course Description, reviewed the table of contents of your textbook, checked the curricular requirements on AP Central, and read through the various syllabi in this chapter, it is time to tackle the arrangement of your own academic year. Ample review time is necessary prior to the AP Exam in May. You might want to look at your plan in reverse; that is, using your school calendar and the date of the exam, plan backward from that time. For example, because our school is on trimesters, I look at the year in thirds. I make a grid of 12 weeks on a page and map it out by textbook sections, with the last segment ending approximately a week prior to the AP Exam. After accounting for school holidays, trimester exam periods, and the ever-present "special school event" schedules, I work my way back to the beginning of the year. Included in my grid are lesson days, test days, review days, computer days (it is a struggle to get the lab), and several data-gathering days.

You may need to make allowances for the fact that certain sections of your textbook require more time than others. Different items in the Topic Outline take varying amounts of time. In some lessons I may be able to check two items off the list in a day, but others may take a week. I may actually spend less time reviewing than other instructors do, because my students have already received a great deal of practice with AP free-response questions throughout the year. If you are a new teacher of this course, I would suggest aiming for two weeks of review, if possible.

During this review time I tend to concentrate on sample multiple-choice questions and some of the more challenging investigative tasks. I also give students one of the AP Statistics Released Exams to complete and score (giving them insight into the scoring process as well as putting them in the exam-taking environment). It is important for them to see a complete set of multiple-choice questions and realize that this section emphasizes concepts over computation. There is a marked difference between the 1997 and 2002 Released Exams. The advent of calculators with statistical capabilities has changed the nature of many of the questions, and most of the calculator-driven multiple-choice questions on the 1997 exam had been eliminated by 2002. The latter exam is much more representative of what students should expect to see each May. The 2007 exam has now been released, and a complete Statistics Practice Exam is available on AP Central to teachers whose syllabi have been approved in the Course Audit process, providing more problems for you to use.

Working with previous AP Exam questions throughout the year and discussing the scoring guidelines communicates the level of preparedness that will be expected on the exam. It also emphasizes that success is not derived from calculations alone. Justifying procedures and interpreting results in a math class will be a new experience for many students. Give them lots of practice. Have them strive for clarity in their writing as well. Reviewing the model solutions in the published scoring commentaries is always instructive for students. It is helpful to give some of these old problems as timed-writing exercises.

First Things First

As I designed my syllabus, I knew I wanted to include a minimum of one data-centered activity each week (such as comparing the dexterity of students' left and right hands, or determining how many candies must be sampled before finding a green one), so I made that a priority in planning what to teach and when. Inspiration for activities came from statistics books, the AP Statistics Electronic Discussion Group, and suggestions from experienced teachers. The next task was to convince my district to provide funds to buy supplies for the activities, such as Barbie® dolls from thrift stores, multicolored candy, duct tape, dried beans, dice, cards, ice cream, and inflatable beach balls that looked like the earth. Finally, it was time to map out the course. With the aid of a school calendar and textbook, I blocked out two weeks of review time at the end of the year and allowed for school activities and vacations. The remaining instructional days were budgeted by the amount of emphasis each topic was given in the AP Course Description—but I made sure there was at least one data-focused exercise each week. Flexibility in planning a syllabus is essential, however, so after each year's AP Exam I analyze my students' strengths and weaknesses and adjust instructional days accordingly.

—Joyce Smart, Logan High School,
Logan, Utah

You will also need to decide how much of a role the calculator will play in your classroom. You will want to include some calculator-based activities, which are useful for data exploration, conducting simulations, and easing the tedium of excessive arithmetic. However, do not let students use the calculator as a shortcut or an excuse for not showing their work! When working with probabilities, z values, and t values, it is a good idea to switch back and forth between using the calculator's built-in probability distributions (found with the calculator keystrokes "2nd DISTR") and using the tables available for the AP Exam (tables A, B, and C in the Formulas and Tables section of the Course Description). Students should have facility with both approaches, but some may have a decided preference. The pitfalls of using "calculator-speak" are discussed in chapter 4.

As you read the sample syllabi in this chapter, search the Web, visit the AP Statistics Course Home Page, and go to workshops, you will undoubtedly come across many interesting and exciting activities that you will want to try, but as a new teacher of the course you may need to exercise some restraint. Your first responsibility is to complete the course in a timely fashion. Some of these activities might be better left to subsequent years when you have the course content under your belt and a better notion of pacing. Rarely do we get the timing exactly right the first year.

Student Projects

Many teachers of introductory statistics say that student projects are an indispensable part of their course. A student project is one in which a student or a group of students define a problem, collect data on that problem, analyze their data—including the use of appropriate graphical displays—and write a report on their conclusions or present an oral report to the class. Try to incorporate such projects into your plans. Until students "get their hands dirty," many may not appreciate the fine points of doing research that involves the collection and analysis of data. Letting your students wrestle with data they have gathered themselves can be very instructive and makes the course more personal. You might consider doing one simple project each semester during the first year and expanding after that. Remember that you will have to grade projects and still keep up with the current material. To keep from being overwhelmed by the grading, one new teacher who had a very large class assigned a project in which students were required to work with a partner. The students still benefited from collecting and analyzing data, but the teacher's grading workload was cut in half. The debates students have with each other when developing a report are also highly effective learning experiences.

Projects can be short or can require many weeks to complete. You will find many examples of projects in the Student Activities sections of the sample syllabi presented in this chapter. A number of projects are described in the 2002 *AP Statistics Teacher's Guide* as well. The 2002 guide is something a veteran teacher of the course should have in his or her possession. You might be able to borrow one from a colleague in your area. You can also look at experienced teacher Web sites to find lots of examples. I suggest starting with Al Coons's site (www.bbn-school.org/us/math/ap_stats). One further source is the AP Statistics Course Home Page, where a link to the section "After the Exam: Activities and Projects" appears under the *Teaching Resource Materials* heading. A good suggestion is to keep some of the best projects from your previous year(s) to use as examples in the next. This will usually raise the quality of student work.

Learning by Doing

Nothing helps students consolidate their knowledge like a project. As much is learned from the iterative process of designing the study and collecting data as from writing the final paper. Full-blown projects might include sections on research questions/variables, sample selection/randomization, data collection methodology, data presentation, statistical test/analysis, a discussion of results, weaknesses/suggested improvements, and conclusion.

Projects are time-consuming and should be spread over several weeks. The most instructive ones allow students to find topics related to their own interests while still meeting the teacher's detailed expectations. Expect multiple proposals that grow in length. Allowing students to evaluate others' proposals is very effective. Large sample size is less important than the process. Simple random samples are rarely available. Many real questions are first studied with small sample sizes. Surveys or using published data takes less time, but actually measuring (how far golf balls travel when hit with different clubs) or counting (do women drive SUVs more often than men?) can be more satisfying.

Check each paper against your list of expectations, but grade holistically as you would for a history paper (see "A Guide for Scoring Free-Response Statistics Questions" in the *AP Statistics Course Description* (pp. 29–30 in the 2009, 2010 edition). Examples of projects can be found by searching the Web for "AP Statistics project" or at my class Web site: www.bbn-school.org/us/math/ap_stats.

—Al Coons, Buckingham Browne & Nichols School, Cambridge, Massachusetts

Build in Time for Student Projects

One of my favorite things about teaching AP Statistics is that we have time to spend on projects, hands-on demonstrations, and computer labs. When planning my syllabus for a recent school year, I divided the course into five major units: (1) univariate data, (2) bivariate data, (3) survey and experimental design, (4) probability and sampling distributions, and (5) inference. I referred to the sample syllabi in the 2002 *AP Statistics Teacher's Guide* to help me decide how much time to allot for each segment. I then assigned a project for every unit. Some were completed by students individually, and others were partner or group efforts. I made certain to build into my calendar several days in each unit that gave the students time to work on their projects during class in the computer lab. I also set aside time for students to present their projects to the class. We spent the last two weeks before the AP Exam taking practice tests and reviewing test-taking strategies. It is gratifying to teach a course where there is time for students to explore the topics they are learning and to apply them to issues that are of interest to them.

—Lina Ellis, The Westminster Schools,
Atlanta, Georgia

Evaluation

When you use challenging material such as past AP Exam questions on your own tests and quizzes, make sure that your grading reflects the level of rigor of such questions. If performance on these questions counts as part of a student's grade, it is best to score them using the published guidelines and weight them as a percentage of the test. Relatively speaking, in my class the median score on a test tends to fall pretty much in the middle of the B range.

If you use AP Exam questions throughout the year and count them as part of the students' grades, you should consider a grading policy that does not rely on a strict percentage-based system—90 to 100 percent = A, 80 to 89 percent = B, and so on. Students who earn even 80 percent of the points on an AP Statistics Exam could well be on their way to earning an AP grade of 5. Assuming you are scoring a student response with the published rubric, a student who is earning 3 out of 4 points on each free-response question is doing well.

For example, my AP problem sets (two to three previously used questions due each week) count for 5 percent of the grade in the first trimester, 10 percent in the second, and 30 percent in the third. Students thus have a vested interest in completing them, but their grade is not jeopardized early in the year while they are learning how to write a good response for the question. Even then, the percentage grades (out of 28 points) for the seven AP sets completed in the first trimester can be adjusted so that the median class grade approximately corresponds to a B/B- range. By the third trimester, the AP sets are due every six days or so and in aggregate effectively count as much as one of the tests.

Whatever grading policies you use, they should be fair, flexible (so that you can ask challenging questions), and clearly communicated to the students. For example, it is important to think about and establish your expectations when it comes to using published AP Exam questions. Will they serve as review problems only, or will they count as part of the student's grade? Remember that students also have access to the scoring guidelines published on the College Board Web site, so giving AP questions as take-home assignments bears some risk. Will students be allowed to use their notes and textbooks in answering these? May they collaborate? In my school, students may ask either of the two statistics teachers for a hint if they are unsure how to proceed, but they may not use each other or any sources outside their notes and textbook.

Eight Sample Syllabi

Because there is so much variation among schools and diversity among students, eight sample course outlines that illustrate different ways to approach the course are presented in this chapter. Six syllabi come from high schools—public and private, large and small, urban and suburban. Two college syllabi are included as examples of how statistics is taught at the introductory collegiate level. Be sure to read all of the following syllabi—which cover a wide range of academic environments and calendars—even those that you do not think apply to your situation or textbook. They all contain valuable teaching tips and strategies, resources, projects, and suggestions for student activities that you are certain to find useful in your own classroom.

Each syllabus was written by a teacher of a successful statistics course. These instructors have provided information regarding their school environments, teaching strategies, materials, assignments, favorite Web sites and AP questions, resources, post–AP Exam projects, and data-gathering activities. Most important, they share their course planners. It is instructive to examine these for pacing guidelines. Some course schedules are organized by the day and others by the week. This will provide you with a good idea of the amount of time to devote to various topics, such as experimental design, probability, inference, and exploratory data analysis. Note carefully the length of class periods and the number of available days to teach the course, and make adjustments to your own course planner accordingly.

To open this section, two college professors have contributed syllabi, each of which provides a clear example of the introductory postsecondary classes that high school AP courses are designed to reproduce. Katherine Halvorsen at Smith College in Massachusetts includes two lab activities taught by Allison Crawford—exploring tests and confidence intervals for differences in proportions between cars parked in two parking lots and a *Fathom* lab for simulating the distribution of the slope in a simple linear regression model. Jackie Miller at Ohio State University teaches in a quarter system, where the courses are only 10 weeks long. She has therefore provided syllabi for two introductory statistics courses that together comprise most of the high school AP curriculum. She has included some nice activities that can be adapted to the high school classroom, and her course planners contain apt teaching advice within each chapter description as well.

The high school syllabi follow. Michael Allwood, who teaches at Brunswick School in Greenwich, Connecticut, offers a number of AP tips throughout his course planner, as well as some simulation activities that can be done on a calculator. Anne Carroll teaches in a school in Kennett Square, Pennsylvania, an area with a substantial immigrant worker population. She favors a Socratic method in her teaching and uses a pair-share technique for student learning activities and labs. Dora Daniluk comes from a large suburban high school in Houston and includes quite a few class activities and applets, along with restaurant and helicopter projects that she has done. From Rancho Cucamonga High School, near Los Angeles, Jared Derksen shares one of his crossword puzzles, some of his favorite AP questions that he uses in class, and his end-of-year cumulative project. Jeane Swaynos, from Seminole High School in Sanford, Florida, presents some good ideas for working with diverse classes that include both highly motivated and more challenged students. Josh Tabor's syllabus for Glen A. Wilson High School in Hacienda Heights, California, explains his use of partially completed notes to save some class time. He includes an example of this, as well as his daily planner, homework assignments, and favorite AP questions. Since writing this, Josh has changed schools. He is now at Canyon del Oro High School, in Tucson, Arizona, where he is using the same textbook but on a block schedule. He reports that he is "basically doing everything the same way, except doubling up lessons on the block schedule days."

Important Note: The AP Course Audit

The syllabi included in this Teacher's Guide were developed prior to the initiation of the AP Course Audit and the identification of the current AP Statistics Curricular Requirements. These syllabi contain rich resources and will be useful in generating ideas for your AP course. In addition to providing detailed course planners, the syllabi contain descriptions of classroom activities and assignments, along with helpful teaching strategies. However, they should not be used in their entirety as models that would be authorized under the guidelines of the AP Course Audit. To view the current AP Curricular Requirements and examples of syllabi that have been developed since the launch of the AP Course Audit and therefore meet all of the AP Statistics Curricular Requirements, go to the Course Audit pages on AP Central (apcentral.collegeboard.com/courseaudit).

Sample Syllabus 1

Katherine Halvorsen, Instructor of Record
Allison Crawford, Laboratory Instructor
Smith College
Northampton, Massachusetts

College Profile

Location and Environment: Smith College is dedicated to the vision of its founder, Sophia Smith, who wrote in 1871 that her intention in endowing a college for women was "to develop as fully as may be the powers of womanhood, and furnish women with the means of usefulness, happiness and honor now withheld from them." Smith is located one hundred miles west of Boston in Northampton, Massachusetts, a vibrant community of 35,000 inhabitants. Most students live on campus in the Smith "house" system. Smith is a member of Five Colleges, Inc., a consortium of colleges in the Pioneer Valley that also includes Amherst College, Hampshire College, Mount Holyoke College, and the University of Massachusetts Amherst. With permission, students may register for classes at any of these institutions.

Some of the most popular majors at Smith are government, psychology, economics, and English. Other majors with large enrollments include art, history, biology, engineering, anthropology, neuroscience, sociology, and Spanish.

The study of statistics at Smith is thriving, with about 300 students a year enrolled in introductory courses offered in departments ranging from Mathematics and Statistics to Economics, Government, Psychology, and Sociology. About 50–70 students each year take upper-level courses, including Regression Analysis, Research Design, Econometrics, and Mathematical Statistics. Majors in mathematics can concentrate in statistics, and majors in other fields can complete a minor in applied statistics. At least one course in introductory statistics is required for majors in biology, engineering, neuroscience, and psychology.

Type: Private liberal-arts college for women

Total Enrollment: There are approximately 2,800 students, of which about 300 are away from campus annually, participating in junior-year programs or internships abroad and across the United States. About 20 percent are first-generation college students. The student–faculty ratio at Smith is 9 to 1.

Ethnic Diversity: Approximately 30 percent of students have minority standing (Asian American, 14 percent; African American, 7 percent; Latina, five percent; Native American, 1 percent; multiracial, 1 percent). Six percent are international students coming from 26 countries.

AP Policy

Smith College participates in the College Board's Advanced Placement Program. AP credit may be used with the approval of the Administrative Board only: (1) to undertake an accelerated course program; (2) to make up a shortage of credit incurred as a result of dropping a course for reasons of health; or (3) to make up a shortage of credits incurred through failure. Credits are recorded for scores of 4 or 5 on most AP Exams. A maximum of one year (32 credits) of AP credit may be counted toward the degree. Students who complete courses that cover substantially the same material as those for which AP credit is recorded may not then apply that AP credit toward the degree requirement. The credits to be recorded for each examination are determined by the individual department.

Personal Philosophy

Students learn statistics by using statistics in contexts that have meaning for them. The subject only has value to the extent that they can see where and how it fits into their personal or working lives. Therefore, they must be able to relate what we are doing in this course to questions they have asked, or discussions they have had, outside of statistics class. To that end, I bring to class a wide range of studies reported in newspapers, magazines, and journals, as well as on the Web, in order to connect with as many students as possible. We discuss the design and analysis of these studies, and for their term project, students pose their own research question, design a study, collect and analyze the data, and present the results at a poster session on the last day of class. Students need to find their own voices in writing about statistical issues, and I emphasize the importance of communicating clearly, in writing, the methods and findings of statistical analyses.

Class Profile

MTH 245, Introduction to Probability and Statistics, provides an introduction to statistics primarily for mathematically mature students who are majoring in the sciences or mathematics. They have already taken at least one semester of college calculus or one year of high school calculus. Students who received a 4 or a 5 on the AP Statistics Exam are encouraged to enroll in the second-level statistics courses, either Research Design or Regression Analysis. A little over half of the 40 students who typically enroll in MTH 245 major in biology, biochemistry, environmental science, or neuroscience. Another 15 percent major in the mathematical sciences; 15 percent come from the social sciences; 15 percent have not yet declared a major; and the remaining 5 percent include students from the other sciences and the arts. Many of these students plan graduate school and careers in biology, neuroscience, medicine, or other sciences. Some of the math majors plan to become high school mathematics teachers. Most students take the course in their first or second year at Smith, and they start using what they are learning almost immediately, in courses such as neuroscience, genetics, ecology, and population biology.

Classes meet Monday, Wednesday, and Friday for 70 minutes. Students are expected to attend class, as participation is an important part of the learning process and essential to stimulate discussion. Labs meet for 80 minutes on Tuesday and Wednesday afternoons, and students must sign up for one of these sessions. Lectures are delivered by the instructor of record, and the two lab sections are taught by a lab instructor. Laboratory activities form an integral part of the course and are used to explore statistical concepts in greater depth. This may include collecting and analyzing student-generated data and writing reports that interpret the results of analyses in nontechnical language. The labs have their own homework assignments that usually are due at the next lab period.

Course Overview

The aim of this course is to provide students with a thorough understanding of four central topics in statistics: study design, exploratory data analysis, probability models, and statistical inference. The prerequisite is any of the following: Calculus I, Discrete Mathematics, one year of high school calculus, or permission of the instructor. Students who have not taken calculus or discrete mathematics but have taken four years of high school mathematics should enroll in Statistical Methods for Undergraduate Research (MTH 190). Students with three years of high school mathematics should enroll in Statistical Thinking (MTH 107). MTH 245 satisfies the basis requirements for a statistics course in the Biology and Psychology Departments (“basis courses” at Smith are the courses all majors have to complete before taking more advanced courses to satisfy the degree requirements in their major).

Text

Text for the course is the fifth edition of *Introduction to the Practice of Statistics* by David S. Moore and George P. McCabe. Students find the textbook very readable. It is full of outstanding examples of real statistical studies in the sciences and social sciences. We discuss most of the topics covered by the text, but we modify the order and start with chapter 3, “Producing Data,” because we want the students to start thinking about their course projects right away.

The rest of the course is best summarized in the following information that is adapted from material addressed directly to the students and provided on the first day of class.

Learning statistics is like learning a new language. There are new ideas, new vocabulary, and new rules. The pace of this course is moderate but *relentless*, so it is essential that you do not fall behind. The exams, quizzes, homework, and project assignments are scheduled to encourage steady, consistent application on your part. It is crucially important that you read ahead in the book as well as review the material after we have discussed it in class. There is no better way to learn statistics than to tackle problems in the text, working examples and wrestling with the exercises (many of which have solutions at the back of the book).

Class time is spent discussing your questions, looking at other examples, and engaging in activities. We also show you how to use statistical software to do the extensive computations most statistical problems require. The computer is usually faster and more accurate than we are at doing arithmetic and graphs, but we have to know what arithmetic and which graphs will be useful.

We recommend that you form study groups of three or four students and get together outside of class to discuss the homework. Each of you should try the problems on your own and then meet to discuss your work. This allows you to develop your own way of thinking about statistics problems before hearing how others think and helps you to gain self-confidence.

We also suggest that you create a three-ring binder devoted to this course so that you can collect all of the course notes, lab notes, handouts, project drafts, homework papers, tests, quizzes, and related materials in one place.

Course Web Site

We have a Moodle Web page [an open-source, Web-based course management system] for MTH 245, and course information, including this syllabus, is available there. We regularly update information posted there with class handouts, homework and project assignments, and announcements.

Statistical Software

We use *Minitab* statistical software that is available in many computer labs on campus. *Minitab* has an online manual, and we will show you how to use the program and how to use the online help facilities. Additionally, your textbook publisher offers statistical applets and practice quizzes online, which we explore during class. We also use practice quizzes from the ARTIST Web site [see Teachers’ Resources at the end of this syllabus], and we will let you know when those are available.

Calculator Policy

You must bring a scientific calculator to class and to each test and quiz. You are not allowed to share a calculator with another student during either a test or a quiz. You do not need a graphing calculator, but your calculator should be able to take logs and exponents.

Homework

Homework is an important way to reinforce concepts learned in class. Problems are assigned each week, and the assignments, with their due dates, are posted on Moodle. We strongly encourage you to complete these and to work other problems if you need more practice. You may discuss the homework problems with your colleagues, but you must write up your own solutions. Homework problems are due at the beginning of class on the due date and must be handed in on time to receive full credit. Homework handed in during class or at the end of class is automatically late, and late homework will not be accepted after the first class following the due date. Absence from class does not permit you to hand in homework after the due date without penalty. If you know you must miss class on the due date, your homework may be handed in early.

Quizzes

Weekly quizzes are given every Wednesday during the first 10 minutes of class. Part of the content of these quizzes is directly related to the reading assignments due that day, and the questions are very easy if you have, in fact, done the reading. This helps ensure that everyone is at the same level when a topic is discussed. The rest of the quiz content is review material and serves to keep your skills honed. In statistics, perhaps even more than in other endeavors, you learn by doing. There will be no makeups, but your lowest quiz score will be dropped. Quizzes count only 10 percent toward your final grade. They are intended to provide just enough extra motivation for you to do your reading on time and to review your notes after every class. If they succeed in doing this, they are likely to reduce your workload, not increase it.

Tests

The two midterm examinations will be held on February 23 and March 30. You are allowed to bring some personal notes to these tests. We will give explicit instructions before each test. The final examination will be self-scheduled during the final examination period in May. If you have special needs concerning test-taking, please discuss them with Professor Halvorsen. Recall that Smith College has had an academic honor code since 1944, and all students are bound by it. Cases of dishonesty or plagiarism will be sent to the Academic Honor Board. Makeup exams may be given to students who notify Ms. Halvorsen, in advance, that they cannot take a scheduled midterm and who have an appropriate explanation for their absence. Makeup exams may be oral or written at the discretion of the instructor.

Term Projects

You are expected to complete a research project of your own choosing during the term and to present your results in a poster on the last day of class. These projects consist of collecting and analyzing data and writing about your results. You should start thinking right away about research questions you want to explore. Students work in teams of two or three on the projects. We will give you detailed project instructions and also make these instructions available on Moodle.

Grading

In grading your written work, we look for problem solutions that are technically correct and reasoning that is clearly explained. Numerically correct answers alone are not sufficient on homework, tests, or quizzes. We value neatness and brief, clear answers that explain your thinking. If the grader cannot read or follow your work, she cannot give you credit for it.

Course Planner

Spring 2007

The following outline lists each class date and gives the topic that was discussed in that class. The reading assignment from the textbook is also given for each class date. *IPS* = *Introduction to the Practice of Statistics*; HW = homework.

Date	Topic	Reading	Assignment Due
M/Jan. 29	Introduction, Collecting Data, Types of Studies	*IPS* 3.1	
W/Jan. 31	Planning and Conducting Experiments	*IPS* 3.2	Quiz 1
F/Feb. 2	Planning and Conducting Surveys	*IPS* 3.3	HW 1
M/Feb. 5	Displaying Distributions: Numeric Summaries and Graphs	*IPS* 1.1, 2	
W/Feb. 7	Normal Distributions, *z*-Scores	*IPS* 1.3	Quiz 2
F/Feb. 9	Assessing Normality, Q-Q Plots, *N*-scores	*IPS* 1.3	HW 2
M/Feb. 12	Scatterplots, Median Trace, Correlation	*IPS* 2.1, 2	
W/Feb. 14	Simple Linear Regression (SLR)	*IPS* 2.3	Quiz 3
F/Feb. 16	Residuals, Outliers, Influence Points, and Causation	*IPS* 2.4, 5	HW 3
M/Feb. 19	Exponential Growth, Log Transformations	*IPS* 2.6	
W/Feb. 21	RALLY DAY (NO CLASSES)		
F/Feb. 23	FIRST MIDTERM EXAM		Exam 1
M/Feb. 26	Probability and Randomness	*IPS* 4.1	
W/Feb. 28	Probability Models	*IPS* 4.2	Quiz 4
F/Mar. 2	Random Variables	*IPS* 4.3	HW 4
M/Mar. 5	Means and Variances of Discrete Random Variables	*IPS* 4.4	
W/Mar. 7	General Probability Rules	*IPS* 4.5	Quiz 5
F/Mar. 9	Generalizing from Study Results	*IPS* 3.4	HW 5
M/Mar. 12	Binomial Model for Counts for Small Sample Sizes	*IPS* 5.1	
W/Mar. 14	Approximating the Sampling Distributions for Counts	*IPS* 5.1	
F/Mar. 16	Approximating the Sampling Distributions for Proportions	*IPS* 5.1	HW 6
Mar. 17–24	SPRING BREAK		
M/Mar. 26	Sampling Distribution of the Sample Mean and CLT	*IPS* 5.2	
W/Mar. 28	Confidence Intervals for Means	*IPS* 6.1	HW 7
F/Mar. 30	SECOND MIDTERM EXAM		Exam 2
M/Apr. 2	Tests of Significance	*IPS* 6.2	
W/Apr. 4	Uses and Abuses of Tests	*IPS* 6.3	Quiz 6
F/Apr. 6	Power of a Test, Inference as a Decision	*IPS* 6.4	HW 8
M/Apr. 9	Inference for the Mean, One Sample	*IPS* 7.1	
W/Apr. 11	Inference for Means, Two Samples	*IPS* 7.2	Quiz 7
F/Apr. 13	Inference for a Proportion, One Sample	*IPS* 8.1	HW 9
M/Apr. 16	Inference for Proportions, Two Samples	*IPS* 8.2	

Date	Topic	Reading	Assignment Due
W/Apr. 18	Data Analysis for Two-Way Tables	*IPS* 9.1	Quiz 8
F/Apr. 20	Inference for Two-Way Tables, Chi-Square Tests	*IPS* 9.2	HW 10
M/Apr. 23	Confidence Intervals and Tests for Regression Parameters	*IPS* 10.1	
W/Apr. 25	ANOVA Table and *F* Test in Regression	*IPS* 10.2	Quiz 9
F/Apr. 27	One-Way Analysis of Variance: Intuition and Test	*IPS* 12.1	HW 11
M/Apr. 30	One-Way Analysis of Variance: Multiple Comparisons	*IPS* 12.1	
W/May 2	General Review		
F/May 4	Project Poster Session		Project Poster Due
May 8–11	FINAL EXAMS		

Teaching Strategies

Students must keep up with the pace of the course to absorb new ideas presented both in their reading and in class; to that end, we have weekly homework sets and weekly quizzes on the most recent reading and homework questions. Weekly laboratory sessions provide opportunities for hands-on work with problems related to the previous week's reading and class discussions, as well as for practice using computer software to carry out simulations or analyses of data. Students spend class time discussing the material in the reading and working examples. Statistical thinking is emphasized, and we use statistical applets on the Web and hands-on activities to develop concepts.

Learning difficult material is challenging and often frustrating to students. Immediate feedback and easily available help are both important to help keep such frustration within reasonable bounds. I try to return quizzes in the class period following the quiz. Tests, lab assignments, and homework are returned within a week, usually within one or two class periods. Although I have regular office hours each week and make myself available by appointment at other times, my main means of communication with students outside of class is through e-mail and through our Moodle Web site. I post most of the course handouts on the Web. Students can meet with teaching assistants between 7 p.m. and 9 p.m. on Sunday through Thursday evenings to get help, and they can meet with the laboratory instructor during her office hours. I strongly encourage students to form study groups that meet outside of class to discuss class work and homework and to bring questions to class that they cannot solve in their study groups.

Lab Component

Students meet in the statistics laboratory once a week for an 80-minute class. The lab is a required part of the course, and students must attend and do the lab homework weekly.

Each lab section contains between 15 and 20 students. Lab work may require computers or lab equipment (e.g., balances, calipers) for weighing or measuring as students gather data from an experiment. Students typically work in pairs or larger groups for most lab activities.

There is no "lab manual"; instead, we hand out plans for each lab during the section in which the plan will be used. Below are two examples of the detailed lesson plans given to students. Each lab plan contains some objectives and an activity for that day's lab and, usually, a homework assignment.

LAB 10: Exploring Tests and Confidence Intervals for Proportions Through Data Collection and Analysis

Objectives

- To learn methods for constructing tests and confidence intervals for proportions
- To acquire experience applying the methods for testing a hypothesis and for constructing a confidence interval for the difference in proportions from two populations

Description of the Activity

We want you to develop a research hypothesis about a difference in proportions between the cars that park in two Smith College parking lots. Consider the following possibilities, but you are not limited to these comparisons. Discuss other options you may wish to pursue with your lab instructor before you start to take measurements.

Proportion of SUVs in each lot

Proportion of vehicles sitting on the white line that defines the parking place

Proportion of vehicles with one or more bumper stickers

Proportion of vehicles with something dangling from the rearview mirror

Write here what you plan to compare:

Explain why you think your data will meet the criteria needed to ensure the validity of a confidence interval or a test of two proportions (that is, what the assumptions are and why you think your data will satisfy them).

Methods

How are you going to decide whether a vehicle has the characteristic you are going to count? For instance, how much of a vehicle's tire must be on the line before it counts as "sitting on the white line"? Give an operational definition of the variable you plan to count below. Provide as much detail in your description as you would need to instruct someone else to collect these data for you.

Data Collection

Decide how you are going to collect and record your data (including mechanisms to ensure that your group does not count the same car twice). Attach your data collection record to your lab report.

Inference Procedure

1. Report your summary statistics (for example, the total number of vehicles in each lot, the number of vehicles in each lot that had your characteristic of interest, the sample proportion in each lot, and the standard deviation of the sample proportion in each lot).

2. Describe your research question.

   a. What is your null hypothesis? What is the alternate hypothesis?

   b. What α level will you use for this test?

   c. Under what condition will you reject the null hypothesis?

3. Conduct the test you described above.

4. Construct a 95 percent confidence interval for the difference between the two proportions.

5. Report your conclusion in context.

LAB 11: Simulation of the Distribution of the Slope in a Simple Linear Regression Model

(The original idea for this lab came from Robin H. Lock, the Jack and Sylvia Burry Chair in Statistics at St. Lawrence University. It is designed for use with *Fathom 2*.)

Objectives

- To gain an understanding of the simple linear regression model
- To observe the sampling distribution of the slope of a regression line
- To be able to use *Fathom* to generate data, take samples, and plot graphs

Description of the Activity

We have seen the least squares regression line $\hat{y}$ = a + bx as a description of a linear relationship between a response variable y and an explanatory variable x. Now we have learned that the least squares line computed from a sample is an estimate of a true regression line for the population, just as x-bar is an estimate of the true population mean μ. The notation for population regression line is $\beta_0 + \beta_1 x$, and for sample data, it is $b_0 + b_1x$. The intercept b_0 of the fitted line estimates the intercept β_0 of the population line, and the slope b_1 estimates the slope β_1.

The statistical model for simple linear regression assumes that for each value of x_i, the possible values of the observed response variables y_i are normally distributed about the mean E $[y_i \mid x_i]$. Moreover, b_0 and b_1 are approximately normally distributed with means β_0 and β_1 respectively. This result depends on the assumption that the error terms ε_i in the model $y_i = \beta_0 + \beta_1 x_i + \varepsilon_i$ are independent and normally distributed with mean 0 and standard deviation σ. In this lab, we will use *Fathom* to simulate the sampling distribution of a slope b_1. We draw random samples from a bivariate population, (x_i, y_i), compute the fitted regression line for each sample, and show that b_1 are normally distributed with mean β_1.

<u>Generating the Population Regression Line</u>

1. Open *Fathom*.

2. Pull the **New Collection** box off the tool shelf. Double-click on the default name **Collection 1** to rename the collection box as **Population**.

3. Generate 1,000 observations for the **Population**. You will see golden balls filling the collection box.

   - **Collection → New Cases → 1,000**

4. Right-click on the **Population** box to open the **Inspect Collection** dialog box.

   - Click on the **Cases** pane.

     a) Fill in a variable name under the heading **Attribute**, for example, **X**.

     b) Fill in the formula by double-clicking in the blank box below the heading **Formula**. Enter **prev (X) + 1** in the formula box. Click **OK**. You should see the formula below the **Formula** heading, and **1** (the value for the first observation) appears below the **Value** heading. We have created a sequence of values from 1 to 1,000 in ascending order.

c) Fill in the next variable name, **Y**.

d) Enter **10 + 3 X** in the formula box. Click **OK**, and you will see **13** in the **Value** box for the first observation.

e) Fill in the third variable name, **YRand**. That is the y value when a random error ε_i is included.

f) Enter **Y + RandomNormal (0, 10)** in the **YRand formula** box. We are adding the random error ε_i, which has mean 0 and standard deviation 10 to **Y**. **RandomNormal** instructions can also be found by choosing **Functions** → **Random numbers** → **randomNormal**.

<u>Taking Random Samples from the Population</u>

5. Highlight the **Population** box, and go to **Collection** → **Sample Cases**. A new box named **Sample of Population** will appear.

6. Right-click on the **Sample of Population** box, and open the **Inspector Collection** dialog box.

7. On the **Sample** pane

   - Turn off animation (uncheck the box in front of **Animation on**).
   - Keep **With replacement** and **Replace existing cases** on.
   - Collect 25 cases by entering **25**, and click on **Sample More Cases**. That is the size of our sample.

8. On the **Cases** pane, you should see all three variables.

9. On the **Measures** pane, enter **Slope** under **Measure** and enter **linRegrSlope (X, YRand)** in the formula box. The formula can also be found by choosing **Functions** → **Statistical** → **Two Attributes** → **linRegrSlope**.

<u>Collecting Measures from Samples</u>

10. Highlight the **Sample of Population** box, and go to **Collection** → **Collect Measures**. A third box named **Measures from Sample of Populations** will be there.

11. Open the **Inspector Collection** box by right-clicking the **Measures from Sample of Populations** box.

12. On the **Collect Measures** pane

    - Turn off animation.
    - Keep **Replace existing cases** on.
    - Collect **500** measures.
    - Click on the icon **Collect More Measures**.

Making Graphs for Values of Slope

13. When it is done, open the **Cases** pane.

14. Pull a **Graph** off the tool shelf. Make a histogram for values of **Slope** by grasping the variable **Slope** from the **Cases** pane and dropping them on the horizontal axis. Choose **Histogram**.

15. Right-click on the graph, and choose **Plot Function**. Key in the formula: **normalDensity (slope, mean( ), s( )**), and click **OK**. You should be able to see a normal curve being fitted to the histogram.[8]

16. Take a **New Graph** off the tool shelf and make a **Normal Quantile Plot** for the values of **Slope**.

Showing the Classical Summary and the Five-Number Summary

17. Pull the **Summary** icon from the tool shelf.

18. Grasp **Slope** from the **Cases** pane, and drop it onto the **Summary** table.

19. The mean will be immediately displayed as default.

20. Right-click on the **Summary** table box, and choose **Add Formula**.

21. The standard deviation of the distribution can be found by choosing **Functions** → **Statistical** → **One Attribute** → **stdDev**.

22. Produce the five-number summary in the summary table by using **Functions** → **Statistical** → **One Attribute** → **…**

23. Use the information from your graphs and summary statistics to comment on how well the normal distribution approximates the observed distribution of slope. Use a text box to insert your answer on the screen page. To insert a **text box**, go to the text icon on the tool shelf **A**, and pull the box off the shelf. Type your answer inside the box. You may resize the box by dragging on a corner.

Finding the 95 Percent Confidence Interval for the Mean of the Distribution of Slope

24. Theoretical estimation

    - Pull the **Estimate** icon off the shelf.
    - Choose **Estimate Mean** under **Empty Estimate**.
    - Grasp and drop **Slope** onto the first line that contains **Attribute (numeric): <unassigned>**.
    - You should see all the analysis about the confidence interval you need.

8. Note that by moving the cursor over the histogram, you can see a hand, a double-headed horizontal arrow, or a single-headed arrow. The hand symbol, held over a bar in the histogram, causes the program to report both the upper and lower values on the horizontal scale for the bar, and the number of observations in this interval. These numbers are shown in the lower left-hand corner of the screen, just above the **Start** button. For example, **2.987 <= Slope <= 2.989: 25 cases** means that there are 25 values of the variable **Slope** between 2.987 and 2.989. The double-headed horizontal arrow, held over a vertical line, causes the program to report the X-value of the vertical line. The single-headed arrow causes the program to report the (*x, y*) coordinates of the point at the tip of the arrow.

Finding the 95 Percent Prediction Interval for a New Observation by Theoretical Estimation and by Empirical Estimation

25. Theoretical estimation

    - The 95 percent prediction interval for a new observation is: $\hat{y} \pm t^* \text{SE } \hat{y}$, where t^* is the value for the $(n-2)$ density curve with area 95 percent between $-t^*$ and t^*.
    - t value for 498 degree of freedom at 97.25 percent is 1.9647.
    - Insert your answer in a text box.

26. Empirical estimation

    - Highlight the collection box, **Measures from Sample of Population**.
    - Pull the **Table** icon from the tool shelf. You should be able to see all 500 estimates of the slope in the table.
    - Click on **Slope** in the table, and all the values will be highlighted.
    - Right-click, and choose **Sort Ascending**. The 500 values will be arranged in ascending order.
    - Take the average of the twelfth and thirteenth values and also the average of the four hundred eighty-seventh and four hundred eighty-eighth values. These two numbers estimate the range of the middle 95 percent of the distribution.
    - Create a **text box**, and record your empirical prediction interval in the text box.

27. Compare the two prediction intervals, and give an explanation for any discrepancy you may find. Use another text box for this discussion.

Assignment

Produce a lab report that includes the histogram, normal quantile plot, numerical summary, point estimate, 95 percent confidence interval for the mean slope, the two prediction intervals for new observations, and your comments.

Student Evaluation

The semester grade for this course is a weighted average of several components, as indicated below. In borderline situations, class participation and attendance are given greater emphasis.

Participation	5 percent
Quizzes	10 percent
Homework	10 percent
Lab work	15 percent
First midterm	15 percent
Second midterm	15 percent
Final exam	15 percent
Projects	15 percent

The lab instructor grades the lab homework and provides the course instructor with an overall lab grade for the semester. This grade is then averaged into the course grade as shown above. Homework is marked by a grader using an answer key provided by the instructor. Each homework assignment is graded from 1 to 5 points, based on a combination of accuracy and effort. Below are rough guidelines for grading:

5—all problems completed with detailed solutions; 75 percent or more correct

4—all problems completed with detailed solutions; 50–75 percent correct; OR close to all problems completed; 75–100 percent correct

3—close to all problems completed; less than 75 percent correct

1—more than half but fewer than all problems completed; 75 percent correct

0—no work submitted; no work also means submitting very few of the problems and showing no detail/work to the solutions

Both midterm exams and the final exam follow the format of the AP Statistics Exam. The midterms have 8 to 10 multiple-choice/fill-in-the-blank questions and 4 free-response questions. Students have an hour and 10 minutes to complete the exam. They may bring one 8½ by 11 inch sheet of handwritten notes to each midterm and to the final exam. These can be any notes they want to bring. I see the preparation of these notes as a way for students to review and summarize the course material. They have to decide what was important and what they need to bring to the exam to help them remember the details correctly. Students must hand in the notes so that I can look at them when I am grading the exams. I sometimes check to see what a student has written in her notes when she gets a question wrong.

Final exams at Smith are “self-scheduled” over a four-day period. A student may pick up her exam from a central location staffed by the registrar’s office, take it to a designated classroom, complete it within 2 hours and 20 minutes, and return it to the table where she picked it up. Students can take their exams in any order and at any of the scheduled times within those four days.

There is no standard grading scale at Smith. I average the grades at the end of the term and give A’s to students with averages between 90 and 100, B’s to students with averages between 80 and 89, and so forth.

Teacher Resources

Textbook

Moore, David S., and George P. McCabe. *Introduction to the Practice of Statistics*. 5th ed. New York: W. H. Freeman, 2005.

Other

ARTIST (Assessment Resource Tools for Improving Statistical Thinking). https://app.gen.umn.edu/artist/index.html.

Provides a variety of assessment resources for teaching first courses in statistics.

Fathom Dynamic Data Software. Version 2. Emeryville, Calif.: Key Curriculum Press. www.keypress.com.

Student Activities

Class Projects

The following student handout explains in detail all the requirements of the semester-long research studies that the students develop and implement, either individually or with a partner.

For your class project you will select a research question that interests you and write a proposal describing how you plan to conduct your research. We encourage you to work with another student on your project. You will review other students' proposals, and you will receive reviews of your proposal from your peers, from the instructors, and, for some of you, from Smith College's Institutional Review Board. After your research proposal has been approved, you will carry out your data collection and analysis. Finally, you will create a poster describing your study and your results. Posters will be displayed in the style of a professional conference on our last day of class. Each of you will be assigned to review three of the final posters.

The following steps lead to a completed class project:

- Project outline, due Monday 2-5
- Project proposal, due Friday 2-16 (please hand in three copies)
- Peer review of proposals, due Monday 2-19
- Revisions (if needed) to project proposal, due Monday 2-26
- Progress report, due Monday 3-12
- Copy of project data and descriptive statistics, due Monday 4-2
- Preliminary data analysis, graphs, and tables, due Monday 4-16
- Poster draft, due Monday 4-23
- Project poster, due Friday 5-4
- One-page abstract of project, due Friday 5-4
- Peer reviews of three posters, due in class Friday 5-4

The project may be either of the following types:

1. <u>An original experiment or observational study</u>: You might conduct an experiment (for example, collect data on which type of nail polish lasts longest), or you might survey a sample of students on some topic that interests you. Your project will involve developing an observational or experimental protocol or a survey, selecting a sample or assigning available units to treatments, collecting and analyzing the data, and drawing conclusions.

2. <u>An analysis of an existing data set</u>: You may be able to apply the techniques we learn in this course to a data set that already exists. The Internet has a vast array of data sets on a wide variety of subjects, such as demographics, disease, economics, geography, entertainment, science, and women's issues. You may also obtain data sets from local businesses or government organizations. Alternatively, a professor you know or are working with may have a data set you could analyze.

General Rules

The work (analysis and write-up) must be your own. You may consult other sources for information about the nonstatistical, substantive issues in your project, but be sure to credit these sources in your poster. Consult the instructors about statistical questions. *Projects that involve using human subjects (interviewing, measuring, etc.) or live animals must be reviewed by the Institutional Review Board, and you need to allow time for this in planning your project*. Institutional review ensures that the subjects will be treated properly, their privacy protected, and their consent obtained. If you need to use human subjects, we will show you how to prepare a proposal for institutional review.

Project Outline

The project outline consists of a one-page form on which you very briefly describe your proposed project. One copy of the blank form is attached to these instructions, and the form is also available on Moodle at our class site. We will use this information to work with you to develop your full project proposal.

Project Proposal

The proposal for your poster is a paper, 500–1,000 words in length, that describes in detail the research you plan to conduct and the methods you will use to both collect and analyze your data. The fundamental goal of any proposal is to convince the reviewer that your objectives are worthy of the research effort and that you have a plan of action that will result in successful achievement of these objectives. You must hand in three copies of your proposal.

Please be aware that the instructors or the Institutional Review Board may require changes in your proposal before you receive permission to conduct your study. We will work with you to ensure that your proposal will be approved. Be sure to use the format given below for your proposal and to address each item in the outline.

The proposal must be typed, double-spaced, on 8½ by 11 inch white paper. Include a cover sheet with the following information: the names and contact information for the authors, the course number and name, the date, and the course instructors' names. On the cover sheet state clearly: "This proposal [requires/does not require] institutional review."

Use the following section headings in the body of your proposal.

I. Introduction

What is your topic? What do you already know about your topic? Why is your topic worthy of study? What is the objective of your project? State your research question as one that can be answered through the collection and analysis of data.

II. Methods

A. <u>Sampling Issues</u>

1. What are the units in your study (observations, objects, people, studies)?
2. What is the population from which the units are drawn?
3. How many units do you plan to measure?
4. How will you avoid sampling bias? (You should provide enough detail about your sampling methods so that someone else could collect the data for you.)

B. Data Collection Issues

1. What variables will you measure on each unit in your sample, and how will you measure each variable? (You should measure a minimum of two variables on each unit.) Give operational definitions of your variables and of your methods of measurement. What is the proposed response variable? What are your proposed explanatory or associated variables?

2. How will you collect measurements from the units (for example, will you use a questionnaire to ask questions, or will you directly measure something like height or observe something like price)?

3. Address each of the issues of randomization, replication, and control in your study.

C. Statistical Analyses

1. Are you going to be looking for an association between your two variables or a cause-and-effect relationship? Give your best guess about the relationships between the response and explanatory variable.

2. Note that analysis of your data must include at least one of the following tools:

   - Confidence interval for the difference in two means
   - Confidence interval for the difference in two proportions
   - Test for a difference between two (or more) means
   - Test for a difference between two (or more) proportions
   - Chi-square test for the independence of two categorical variables
   - Test for the significance of the slope of a regression line

3. Describe what graphs and tables you expect to use to display your results. Describe what results you expect to see.

D. Data Collection Form

Provide a copy of the form you plan to use to collect the data. If you plan a survey, then provide a copy of the actual questionnaire you plan to use.

E. Consent Form

If you plan to use human subjects for your study, you must provide them with a statement telling them about your study and asking them for their consent to participate. The consent form must contain all of the following information:

1. Your name, the purpose of the study, and a description of the study. You may not deceive participants or put them at risk in any way.

2. A statement that responses are confidential or anonymous, as appropriate. If the information you are requesting is at all sensitive, you must provide some explanation regarding the steps you are taking to assure confidentiality or anonymity.

3. A request that the subjects voluntarily participate in the study. You should have them sign a consent form if your study is not a survey.

F. Third-Party Information

If you require resources from a third party (for example, using data belonging to someone else), include a copy of your written request to that party for the information. *Do not send the request before you obtain written approval from the instructors.*

Peer Review of a Project Proposal

You will be asked to read and assess someone else's project proposal. Your job is to assess the feasibility and rationale of the project you review. Are the variables the researchers plan to collect appropriate for their research question? Are the data collection methods appropriate? Do lurking variables exist? Is the sample size sufficient? How else could the project be done? Can the objectives be met given the available resources? We will provide a form for your peer reviews.

Progress Report

Midway through the project you need to assess your work to date by completing a progress report. We will give you a set of questions to answer.

Project Data and Descriptive Statistics

By Monday April 2 you should have all of your data collected so that you can begin to focus on the data analysis and on producing a well-organized and attractive poster. At this time you must submit a copy of your data and a report containing descriptive statistics for each variable you collected.

Preliminary Data Analysis

By Monday April 16 a preliminary draft of your complete data analysis is due. This assures that you will have time to complete your analysis and create the poster on time for our poster session on May 4.

Poster Draft

On Monday April 23 please hand in a copy of the text and graphs you plan to put on your poster.

Abstract and Poster Presentation

Bring your poster and a separate abstract for your project to class. The content of your poster should be roughly equivalent to that of a 10-page paper (you do not need to hand in a paper). Your poster should include the following items:

- Title: Invent a catchy or interesting title that captures the spirit of your project.
- Byline: List the authors of the project and their institutional addresses.
- Rationale: Provide a statement of the question or purpose of the project. What problems are addressed, what key issues are important to the project, and what was known about the topic before you started?

- Methods: Explain what you did and how you did it. How did you choose your sample? What variables did you measure? How did you measure each variable? What statistical techniques did you use?
- Results: Present a summary of your data both in figures (graphs or tables) and in a textual description. Emphasize trends as well as specific values. Give the results of confidence intervals or statistical tests.
- Discussion: Explain what you learned about the problem or question you set out to investigate. Discuss your findings in terms of what else is known.
- Critique: What did you learn about the process of carrying out your project? What went wrong, and how could you avoid that pitfall in the future? What advice would you give to future students?
- References: List any sources you used in the poster.
- Acknowledgments: Thank those who helped you with the project.

Creativity, innovation, and humor are all encouraged!

Poster Reviews

On the day of the poster presentation, we will provide forms on which you may write your poster review. It will contain specific questions to address and space for you to provide more extensive comments. We will ask you to consider the following issues:

- Presentation: Is the poster attractive and well organized? Are all components present? Is it easy to follow? Is the text well written? Are the graphs and tables easy to understand?
- Statistical content: Did the investigators use appropriate statistical techniques? Are the techniques used correctly? Are the figures appropriate to the data?
- Subject matter content: Did you learn something about the subject of the poster? Is the content interesting, fun, provocative, compelling, educational, or fascinating?

Students complete a short questionnaire at the end of term after the project is complete. Here are a couple of responses I particularly liked:

Question: What have you learned from the process of conducting your research?

“In conducting my research for the statistics project, I learned that it is very different from conducting a science experiment. Through filling out the IRB form [Institutional Review Board forms required for projects using human subjects], I learned about all of the ethics and meticulous details that must be thought about even when conducting the simplest experiment. I also learned that it really pays off to be organized and get everything done by the helpful deadlines. I also learned how to communicate efficiently with a research partner and how to compromise.”

“Planning and consistent effort matters a lot. Working consistently over the entire assignment period makes the project go a lot smoother. [There is] [m]ore time to make decisions and corrections.”

Sample Syllabus 2

Jackie Miller
Ohio State University, Columbus

University Profile

Location and Environment: In terms of enrollment, Ohio State is the largest university in the United States. It is located in an urban environment about two miles from downtown Columbus, the state capital, in the center of the state. Columbus is the fifteenth-largest U.S. city and the thirty-second-largest metropolitan area. In addition to the university, it boasts many arts and cultural institutions and professional sports teams in soccer, hockey, arena football, and minor league baseball. It is also a major business center.

Ohio State is ranked nineteenth in *U.S. News and World Report*'s 2007 "America's Best Colleges" survey. Its First Year Experience (FYE) and Living-Learning Programs are listed as stellar examples of programs that lead to student success. *Kiplinger Personal Finance* in 2007 ranked the school sixty-second among its top 100 best values in public colleges. Ohio State was also selected in 2003 and 2004 as one of the country's 50 best colleges for African Americans by *Black Enterprise* magazine. More than half (53 percent) of the entering first-year students in fall 2007 ranked in the top 10 percent of their graduating high school class, and 89 percent ranked in the top 25 percent.

There are more than 170 majors at Ohio State. Students can also opt to custom-design their own major through the Personalized Study Program. Undecided students can participate in the Ohio State Exploration Program. The university sponsors nine preprofessional programs (predentistry, pre-education, prelaw, premedicine, pre-occupational therapy, preoptometry, prepharmacy, pre-physical therapy, and pre-veterinary medicine), as well as 28 Agricultural Technical Institute (ATI) programs leading to an Associate of Applied Science or Associate of Science degree.

Type: Coeducational, public research university

Total Enrollment: On the Columbus campus, as of fall 2007, there were 52,568 students (39,209 undergraduates, 10,097 graduate students, and 3,262 professional students). The undergraduate student-to-faculty ratio is 13:1.

Ethnic Diversity: As of fall 2007, the minority student population was as follows: African American, 6.5 percent; Asian American, 5.2 percent; Hispanic/Latino, 2.5 percent; Native American, 0.4 percent. International students from 113 countries accounted for 7 percent of the total enrollment.

Personal Philosophy

I love teaching statistics—despite the fact that I often describe it as selling a product that my students do not want to buy. (This aphorism has also become part of several of my graduate assistants' teaching philosophies.) For many students, statistics is a required course, but regardless of why they choose to take it, most of them really do not know what the subject entails. At Ohio State, for each quarter's course, I have 10 weeks to open up the world of statistics to my students; it is an opportunity to help them consciously realize how statistics influence their daily lives. It is important to me that my students not only learn the process of collecting and analyzing data but that they think critically about the statistics that are presented to them from all quarters: scientific, financial, and political. It is the combination of these abilities that leads my students to be better "consumers" of statistics. This is why selling a product that students do not want to buy is challenging, rewarding, and never dull—the point being proved when some of my students find the course interesting enough to pursue further opportunities in the discipline.

Class Profile

Ohio State operates on the quarter system, and because our courses are only 10 weeks long and could not possibly include all the material included in a yearlong AP Statistics high school class, this syllabus presents Course Planners for two separately taught, one-quarter, introductory statistics courses that together comprise most of the skills included in the AP Statistics curriculum: Statistics 145 (Introduction to the Practice of Statistics) and Statistics 245 (Introduction to Statistical Analysis). The latter is a higher-level course, although it is still introductory in nature. It is not a continuation of Stat 145. For that reason, AP students who earn a grade of 3 on the AP Statistics Exam get credit for Stat 145 and receive five hours of college credit, whereas those who earn a 4 or 5 get credit for Stat 245 and also receive five hours of college credit.

Statistics 145

Students at Ohio State tend to put off this course until later in their college careers. This means that more of my students are juniors and seniors than sophomores and first-year students. Typically, more than half are women. The students come from preprofessional majors in the medical professions, from the social and behavioral sciences, and from the honors program in the arts and sciences.

During the academic year, three lecture sections of Stat 145 are offered every quarter—two during the day and one in the evening, with a different instructor for each. I am the coordinator for the course and always teach one of the daytime lectures. Another faculty or staff member teaches the second daytime lecture, and a senior graduate teaching associate teaches the smaller evening class. We have a total of approximately 400 students in each of the autumn and spring quarters, and about 350 students total in the winter quarter. (During the summer quarter, we offer one daytime lecture that typically serves approximately 100 students.) The evening lecture usually has about 50 students, and the rest of the students are divided equally between the two daytime lectures.

The average number of students per recitation ranges between 26 and 28, depending on enrollment for the quarter. There are typically six recitation sections for each daytime lecture and two recitation sections for the night lecture. This is a five-credit course. The daytime sections (and the summer course) have three 48-minute lectures and two 48-minute recitations per week. The evening class is structured slightly differently, with two 72-minute lectures and two 48-minute recitations per week. The recitations include computer lab work, but there is no separately scheduled lab for the course.

Statistics 245

Statistics 245 has a prerequisite of Calculus II. Even though calculus is not really used in this course, we prefer that the students have the mathematical sophistication that Calculus II provides. Furthermore, I am not aware of any calculus-based introductory statistics books that fit our course.

In the autumn 2007 quarter, the vast majority of the students were juniors and seniors (nearly 80 percent), and three-quarters of them were men. Nearly a third were honors students. In general, the students come from majors in biology, biomedical sciences, engineering, geography, and social and behavioral sciences (economics and psychology students seeking the B.S.). During the academic year, only one daytime lecture is offered (autumn quarter). There are approximately 150 students in the course, and this class meets for three 48-minute lectures and two 48-minute recitations per week. Graduate teaching assistants (GTAs) teach the six recitation sections, which have about 25 students in each. There is no lab component to the course.

Course Overviews

According to our course bulletin, Stat 145 topics include "probability, descriptive statistics, correlation, regression, design of experiments, sampling, estimation, and testing; emphasis on applications, statistical reasoning, and data analysis using statistical software." Stat 245 is described as a "calculus-based introduction to data analysis, experimental design, sampling, probability, and inference."

For both courses, the Web-based statistical software we use is *StatCrunch*, because it has the benefits of *Minitab* and allows us to conduct recitations in both the Mac and PC computer rooms. Ohio State has purchased a license for *StatCrunch*, and our students can access it from within our course management system. We cannot require students to purchase a particular calculator, so this is the closest we can get to students' using the same technology in recitations and on homework.

My broad goals for both courses are similar. The objectives are for students to learn the following:

- Essential techniques for producing data (surveys, experiments, observational studies); analyzing data (graphical and numerical summaries); modeling data (basic probability, sampling distributions); and drawing conclusions from data (inference procedures—confidence intervals and significance tests)
- When and how to use technology to aid in solving statistical problems
- How to produce convincing oral and written statistical arguments, using appropriate terminology
- How to become critical consumers of published statistical results by heightening their awareness of ways in which statistics can be improperly used to mislead, confuse, or distort the truth

Textbooks

For Statistics 145, we use the second edition of *Intro Stats* by De Veaux, Velleman, and Bock. For Statistics 245, the text is the third edition of *Introduction to Statistics and Data Analysis* by Peck, Olsen, and Devore. See the Teacher Resources section of this syllabus for full citations.

Course Planners

Statistics 145: Introduction to the Practice of Statistics

In the past two years, we have lost time during the winter quarter, and I have had to drop confidence intervals and hypothesis testing of the population mean from the course during that term. Because of this, I will use the sequencing from autumn 2006 for the three-lecture-a-week section.

<u>Chapter 1: "Stats Starts Here"</u>

(0 days)

Students are encouraged to read this introduction on their own.

<u>Chapter 2: "Data"</u>

(1.5 days)

This chapter introduces the "how" and the "W's" of data (who, what, when, where, why). Because students find the W's difficult to grasp at first, it is important to emphasize the importance of context in statistics: knowing the answers to the W's makes a study or analysis more meaningful. This chapter also introduces students to the basic differences between categorical, quantitative, ordinal, and identifier variables.

Chapter 3: "Displaying Categorical Data"

(0.5–1 day)

In this chapter, students learn about bar charts and pie charts. These are graphical displays that they should be familiar with from past mathematics (or statistics) classes or from the media. It is important to underscore the pitfalls of each type of display so that students know when they are seeing data portrayed correctly (for example, pictograms typically violate the area principle).

Chapter 4: "Displaying Quantitative Data"

(1.5 days)

The chapter talks about dotplots, stemplots, and histograms (boxplots appear in chapter 5). Because of the limited time in the quarter system, we have chosen to concentrate on histograms. The text asks students to describe the distribution of a data set by shape, center, and spread. The authors include unusual features (outliers, gaps, etc.) in "shape." To emphasize the importance of the unusual features, I separate this category out as a fourth aspect that should be considered when describing distributions. Recently I heard one of my graduate teaching associates split "shape" up even further, telling her students to address modality and symmetry.

Chapter 5: "Describing Distributions Numerically"

(2 days)

This chapter talks about the mean, median, interquartile range, and standard deviation. It also introduces boxplots as another option for graphically displaying quantitative data. Students learn when it is most appropriate to use the mean and standard deviation or the median and IQR to describe, respectively, the center and spread of the distribution.

QUIZ IN RECITATION ON CHAPTERS 2–5

Chapter 12: "Sample Surveys"

(1.5 days)

The important thing for students to understand about sample surveys is when they should question methodology and how different types of bias act on surveys. An interesting question that arises here at Ohio State in association with that issue is why some of us trust electronic Student Evaluations of Instruction (eSEIs), given the fact that Internet surveys are often useless and students must fill out the eSEIs through their own OSU account. We know that no student can evaluate the same course twice, so that problem is eliminated, but it is good to discuss what types of bias may filter into the eSEIs.

Chapter 13: "Experiments"

(1.5 days)

In this chapter, the authors use David Moore's diagram of an experiment to show random assignment, groups, treatments, and comparison of the response variable. The chapter addresses blocking and matched pairs designs as well. I have used two past AP Statistics Exam questions in connection with this chapter—the yoga/tai chi (2003, no. 4) and old/new shampoo (2004, no. 2) experimental design questions.

Chapter 14: "From Randomness to Probability (LLN)"

(1 day)

The idea of "from randomness" in the chapter title is lost a bit in Stat 145 because we do not have time to study chapter 11 ("Simulation") with any justice; simulation is a key element in understanding how we get from randomness to long-run probabilities. To show the law of large numbers during lecture, I use the coin-toss applet linked to the fifth edition of *Introduction to the Practice of Statistics* that can be accessed at http://bcs.whfreeman.com/ips5e by clicking on *Student Applets* and then *Probability.*

One thing in this chapter that I caution students about is that the addition and multiplication rules are specific to disjoint and independent events, respectively. However, the general probability rules in chapter 15 can be used in the special situations encountered in chapter 14.

Chapter 15: "Probability Rules!"

(1 day)

When we get to this point in the course, I remind students that I had foreshadowed the general probability rules of this chapter when we talked about the specific rules for disjoint and independent events. Conditional probabilities are always difficult for students to grasp, but I remind them that we are now formalizing the techniques that we used back in chapter 3 when we looked at marginal and conditional distributions of categorical variables. Another stumbling block for students is the temptation to multiply the probability of events *A* and *B* when finding the probability of the union of those two events. In other words, students tend to make the jump from $P(A \cup B) = P(A) + P(B) - P(A \cap B)$ to $P(A \cup B) = P(A) + P(B) - P(A)P(B)$ without thinking about the implications. Be aware that they may make this misstep and then, in a later exercise, show that the events are not independent. They routinely do not see the contradiction, despite warnings in both lecture and recitation against this common mistake.

Review for midterm exam

(1 day)

COMMON EVENING MIDTERM ON CHAPTERS 2–5 AND 12–15

Chapter 6: "The Standard Deviation as a Ruler and the Normal Model"

(1.5 days)

I teach chapter 6 out of order because it makes more sense to me to have students learn about *z*-scores and the normal distribution right before they need it (the "just in time" approach). This has worked in the class so far, but I understand why the authors have placed chapter 6 where it is in the book and why others would teach the chapters in order.

Chapter 18: "Sampling Distribution Models (CLT)"

(1.5 days)

This chapter deals with sampling distribution models for both proportions and means. It spends a bit more time on proportions than on means: I think this is because the authors move directly into inference for proportions. The sampling distribution is motivated by simulation of data. This can be done and understood without having studied the simulation chapter.

QUIZ IN RECITATION ON CHAPTERS 6 AND 18 (sometimes delayed to include chapter 19)

Chapter 19: "Confidence Intervals for Proportions"

(1.5 days)

The authors introduce confidence intervals in a way that I think makes sense for the class, although students continue to find the process of constructing confidence intervals difficult to understand. One thing that helps is asking them what the probability is that a 95 percent confidence interval contains the true population proportion. Talking about this emphasizes the *process* of constructing confidence intervals. I use the applet linked to the fifth edition of *Introduction to the Practice of Statistics* that can be accessed at http://bcs.whfreeman.com/ips5e by clicking on *Student Applets* and then *Confidence Intervals* to demonstrate the effect of confidence level on the width of the interval. During recitation, students do an activity with M&M's®, one that we feel we have improved over the "typical" version (see Student Activities section at the end of this syllabus). This exercise also carries over to chapter 20, on hypothesis testing.

Chapter 20: "Testing Hypotheses About Proportions"

(2 days)

This is a chapter that students find challenging. No matter how you explain the steps to hypothesis testing, they have a difficult time setting up the hypotheses, making a decision using the *P*-value, and drawing a conclusion in context. Actually calculating the test statistic and the *P*-value are not the stumbling points for these students. However, I think that AP Statistics students have had more time to be exposed to the process of doing and thinking about statistics and may catch on to these steps more easily than other students.

It is important to stress that we use the sample proportion when finding the standard error (and margin of error) for the confidence interval, but we use the hypothesized population proportion when finding the standard deviation for the hypothesis test.

Chapter 21: "More About Tests"

(1.5 days)

This chapter ties confidence intervals and hypothesis tests together, explaining how to use a confidence interval to test a hypothesis. It also talks about errors and power, both of which are eliminated from our coverage in the interest of time. We have discussed having the students read this chapter on their own and getting them involved with an activity that would address the same issues.

Chapter 23: "Inference About Means"

(2 days)

This is a chapter in which I emphasize that we are studying "variations on a theme," the theme being inference. The processes of constructing confidence intervals and conducting hypothesis tests are the same as we have already seen, with slight variations in the distribution and formulas used and the conditions checked. Students do not seem to have a difficult time understanding the *t* distribution, especially when we compare/contrast it with the standard normal distribution.

Chapter 7: "Scatterplots, Association, and Correlation"

(1.5 days)

Again, as can be seen by the chapter numbers, I have chosen an unconventional order for the topics in the introductory statistics course. Because 10-week quarters are so intense, I like to end on an "easier" note and let the ideas from inference settle in with the students over the remaining time in the course. Students have no trouble understanding scatterplots and association. The biggest difficulty with correlation actually comes in chapter 8 when they might see some partial *StatCrunch* output and be asked to state the correlation. It seems that no matter how many times students tell you in class that the correlation is negative when there is a negative association, they still do not pick this out in the final exam question that tests this.

Chapter 8: "Linear Regression"

(1.5 days)

The actual process of doing linear regression and making predictions does not seem difficult for students. They understand that extrapolation is not something they should do (I like to say "Friends don't let friends extrapolate," a slogan that can also be found on an ASA T-shirt!). One concept that is difficult for them to explain on the final exam (which is the only time this is tested) is what a residual plot tells you about the regression.

Chapter 9: "Regression Wisdom"

(1 day)

This chapter is to chapters 7 and 8 what chapter 21 is to chapters 19 and 20. There are important concepts in chapter 9, but I find it a little repetitive, so we are trying to develop a lecture activity that would get at all of the ideas without taking class time to go through the chapter itself (students would be responsible for reading the chapter on their own).

Review for final exam

(2 days)

COMMON FINAL EXAM DURING FINALS WEEK (COMPREHENSIVE)

Statistics 245: Introduction to Statistical Analysis

Autumn 2007 was the first quarter that I taught from this text. The notes that I planned for each chapter took longer than I thought. Thus, the following is a reflection of the content coverage for the syllabus as planned in future offerings of the course. Review for the exams takes place in the recitations.

Chapter 1: "The Role of Statistics and the Data Analysis Process"

(2 days)

In chapter 1, we discuss some basic terminology (e.g., observational units, variables, and categorical and quantitative data). We also examine simple graphical displays (bar graphs for categorical data and dotplots for quantitative data). The idea of central tendency is introduced as a prelude to material to come in chapter 4.

Chapter 2: "Collecting Data Sensibly"

(2.5 days)

In this chapter, we discuss drawing conclusions from studies (including when it is appropriate to do so). We also consider ways to get a proper random sample, along with other methods of sampling (e.g., convenience sample, stratified sample) and their benefits or detriments. Finally, we outline how to properly design an experiment.

Chapter 3: "Graphical Methods for Describing Data"

(1 day)

This chapter is a brief look at dotplots, stem-and-leaf diagrams, and histograms. We also discuss what is needed to describe a distribution (shape, center, spread, and unusual features).

Chapter 4: "Numerical Methods for Describing Data"

(2.5 days)

This chapter examines center (mean, median), spread (range, standard deviation), and *z*-scores. In addition, the five-number summary, the IQR, and boxplots are addressed.

Chapter 6: "Probability"

(2 days)

Here we encounter the basic and general probability rules, along with conditional probabilities.

EXAM 1 IN CLASS ON CHAPTERS 1–4 AND 6

Chapter 7: "Random Variables and Probability Distributions"

(3 days)

In this chapter, we talk about random variables—what they are, what a distribution is, and how to find the expected value, variance, and standard deviation. The specific distributions that we study are the binomial and the normal (including the standard normal distribution and how to read a normal table).

Chapter 8: "Sampling Variability and Sampling Distributions"

(2 days)

This chapter deals with the sampling distribution of the sample proportion and the sample mean. It is important to stress the differences between and among the population distribution, the distribution of a sample, and the sampling distribution.

Chapter 9: "Estimation Using a Single Sample"

(2.5 days)

This chapter introduces confidence intervals for the population proportion and the population mean. The critical issue to emphasize with students is that conditions must be checked to make sure that they can actually go ahead with calculating the interval. Another thing that should be pointed out is that confidence intervals are not complete at the end of the calculation—they need to be interpreted in the context of the problem. This chapter also addresses the calculation of sample sizes.

Chapter 10: "Hypothesis Testing Using a Single Sample"

(3 days)

This chapter introduces hypothesis tests for the population proportion and the population mean. Again, it is important to stress that conditions need to be checked to ensure that students can actually go ahead with calculating the interval and that the conclusions made need to be interpreted in the context of the problem. The link between confidence intervals and hypothesis tests is also discussed.

EXAM 2 IN CLASS ON CHAPTERS 7–10

Chapter 11: "Comparing Two Populations or Treatments"

(3 days)

Here we look at confidence intervals and hypothesis tests for two populations, including the two-sample difference in proportions, the two-sample difference in means, and the dependent sample mean difference. As in chapters 9 and 10, the process of confidence intervals and hypothesis tests are highlighted (including condition checks and interpreting results in context).

Chapter 5: "Summarizing Bivariate Data"

(2.5 days)

This chapter deals with scatterplots, correlation, and simple linear regression. The reason for its placement near the end of the quarter is practical—these are nice concepts to study when the students are tired from a long quarter. This is an introduction to the relationship between two quantitative variables, and bivariate data analysis for categorical variables is discussed in chapter 12.

Chapter 12: "The Analysis of Categorical Data and Goodness-of-Fit Tests"

(2 days)

It is important for students to see bivariate data analysis for categorical variables. Although they worked with categorical variables in the chapters on inference for proportions, which was a special case (the normal approximation to the binomial), they have not worked with categorical variables that have more than two categories since the beginning of the quarter. I feel that they need to be exposed to these procedures so that they remember that quantitative variables are not the only type of variables in the world.

FINAL EXAM DURING FINALS WEEK (COMPREHENSIVE)

Teaching Strategies

During lectures, students use course note packets that I created, based on the *PowerPoint*® slides from the texts but with examples added that are of interest to students. The packets use a fill-in-the-blank format, with room for us to work the examples that I have included for that quarter. Many students like the note packets because they can listen in class instead of furiously writing down notes. This is exactly why I developed them, having learned in my education courses (and from personal experience) that it is very difficult to truly listen to the teacher and copy notes from the board at the same time.

One novel thing that I do in these classes is to use a tablet PC. This allows me to write on *PowerPoint* slides that duplicate the note packet, so I can actually do the work with the students and/or incorporate their suggestions. It is very handy to be able to write down notes on a specific question that students might ask as well. During the Stat 145 lectures, we work through at least one example of each concept; extra examples are saved for recitation. I have been trying to find ways to get students in a large lecture to be more talkative and to participate more. To this end, I question students as much as I can during lecture and ask that they offer solutions to examples or hints on how to approach examples. Occasionally, I set them the task of trying something in their notes and then walk around the lecture hall to help individual students before bringing them back together to discuss their solutions. I also have the class do a lot of voting (for example, which answer is correct?) and hope to include clickers (student response systems) and podcasts within the next year or two. Basically, the teaching strategies for the two courses are very similar, but for Stat 245 the notes are more interactive than those I use in Stat 145. It is up to the students to read the book and to grasp the essentials of the concepts. In class, we work through examples, do simulations, use applets, and engage in an interactive lecture.

In Stat 145, one lecture period is allotted for review for the midterm exam and two periods for the final exam. Quiz review is handled in recitation. For the midterm and final exams, I supply review sheets containing problems similar to those that will be on the exams but that focus on all of the concepts. I always tell my students that if they understand the concepts, they can answer any question, but if they concentrate only on certain types of questions, they might struggle with the concepts. Because of this, I do not provide “practice” exams. Students have both the midterm review and the final exam review in their note packets, so they can start working on those problems at any time. On the days of review, I ask them which concepts they found most difficult, and we concentrate on those questions first before moving on to others (time allowing). Because there is never enough time to finish all of the review questions, I release solutions to the reviews prior to the exams so that students can compare their solutions with mine.

Lab Component

Recitation is the place where students get to ask questions about homework, work on activities, do student presentations, and so forth. The recitations are held in computer labs, so students can actively work with *StatCrunch* in the lab. Each recitation room also has an instructor podium, which allows the graduate teaching associates (GTAs) to project what they are demonstrating for the entire class. In the PC rooms, we have *NetSupport School* classroom management software, which allows the instructor to project her or his screen onto the students’ computer screens and project one student’s screen onto the screen at the front of the class. The instructor can also shut down the computers when they are not being used in recitation so that students cannot “surf the Web” or send e-mail during class.

Recitations take many different forms, depending on the GTA in charge. As part of a functional and productive instructional team, the GTAs share ideas with each other—such as which activities to include (see my Student Activities section for a few examples), "prep questions" that students work on before coming to recitation, "knowledge checks" (mini-quizzes), and how to approach difficult concepts. I like to give the associates room to teach in a style that works best for them (and their students) but to also provide some framework, with extra exercises from the book that they might choose to work on if they cannot think of something else to do—flexibility within a structure is how we all look at it.

All GTAs have their students work in groups for at least some of the time during recitation. Last quarter we tried having students work in groups on smaller, more frequent homework assignments (compared with our control group, which had fewer, longer, individual homework assignments). This quarter we had the students do the more frequent homework individually. We have not yet done a final analysis, but preliminary results indicate that the more frequent group work was not as effective as the longer individual homework.

Student Evaluation

Statistics 145

Students' grades for the course are based on the following components:

Homework (20 percent)
Recitation participation (10 percent)
Quizzes (20 percent)
Midterm exam (20 percent)
Final exam (30 percent)

There are 7–8 homework assignments every quarter, each consisting of 6–11 exercises from the textbook. Each assignment is worth 20 points. Ten points are earned for completion of the homework, and the other 10 are awarded, as appropriate, for accuracy of the solutions. Each GTA grades from a rubric that I provide at the beginning of the quarter. Regardless of the number of assignments, homework counts as 20 percent of the student's grade. For example, if there are 8 homework assignments during a quarter, each is worth 2.5 percent of the student's total grade.

Recitation participation is loosely based on attendance and performance on specified activities. Each GTA has the latitude to determine how recitation participation will be graded, but the students are aware of this structure from the GTA's syllabus. Here are examples of recitation participation guidelines from two different associates:

> Your recitation participation grade will be determined in the following manner: Each recitation is worth 10 points. You will receive 4 points just for attending recitation (only 1 point if you are tardy or leave early) and 6 points for participating in the activity (this includes actively listening, making comments, doing board work, and turning in any worksheets done in class). There are 19 classes this quarter, making the total number of points you can earn 190. I will take the total number of points you earn out of 170 to calculate your participation percentage. (You cannot get more than 100 percent for participation—even if you attend and participate in all 19 classes.)

Your recitation attendance and participation grade will be determined in the following manner:

5 percent knowledge checks

2.5 percent attendance

2.5 percent participation

Knowledge checks are very short closed-book, closed-notes assessments and are designed to help you stay up-to-date with your readings and studying for the course. They are given at the beginning of designated recitations and last about five minutes. You will not be given extra time for the knowledge check if you are late or miss recitation that day. For this reason, I will drop your lowest knowledge-check score. Also note that I will give you about 10 to 20 questions to study for each knowledge check and then choose only a handful of them for the in-class assessment.

Each of the two quizzes given in recitation is worth 10 percent of a student's grade. Each GTA reviews for the quiz for about 25 minutes, and then students are given 20 to 25 minutes to take the quiz. Quizzes are typically made up of 3 or 4 multiple-choice questions and 2 free-response questions. Students are allowed to use one 3 by 5 inch notecard (both sides) with whatever facts, formulas, and examples they want for each quiz. Statistical tables are provided as necessary.

The midterm is given in the evening so that students from both daytime lectures and from the evening lecture can take the exam at the same time. It usually consists of 10 multiple-choice questions and 3 or 4 free-response questions. Students are allowed to use one 8½ by 11 inch sheet of paper (both sides) with whatever facts, formulas, and examples they want for the midterm. Statistical tables are provided as necessary.

The final exam is also given at a single time on the first evening of finals week. Typically, it has 15 multiple-choice questions and 5 or 6 free-response questions. Students are allowed to use two 8½ by 11 inch sheets of paper (both sides) with whatever facts, formulas, and examples they want for the final. Statistical tables are provided as necessary.

Statistics 245

Students' grades are determined based on the following components:

Homework (20 percent)

Two in-quarter exams (25 percent each)

Final exam (30 percent)

There are approximately 10 homework assignments, each of which consists of 6–11 exercises from the textbook. Every homework assignment is worth 20 points. Ten of these points are for completion of the homework, and 10 points are awarded for accuracy. Each GTA grades from a rubric that I provide at the beginning of the quarter. Regardless of the number of homework assignments, homework counts as 20 percent of the student's grade. For example, if there are 10 homework assignments during a quarter, each is worth 2 percent of the student's total grade.

The two in-quarter exams are given during a lecture period. A typical exam consists of 10–15 true/false questions and 3 or 4 free-response questions. Students are allowed to use one 8½ by 11 inch sheet of paper (both sides) with whatever facts, formulas, and examples they want to use. Statistical tables are provided as necessary.

The final exam is given during the time allotted for our course during finals week. It contains 20–25 true/false questions and 5–6 free-response questions. Students are allowed to use two 8½ by 11 inch sheets of paper (both sides) with whatever facts, formulas, and examples they want to have available. Statistical tables are provided as necessary.

For both courses, I use the following grading scale:

		B+	87–89 percent	C+	77–79 percent	D	60–69 percent
A	93–100 percent	B	83–86 percent	C	73–76 percent	F	below 60 percent
A–	90–92 percent	B–	80–82 percent	C–	70–72 percent		

There is no standard scale dictated by Ohio State.

Teacher Resources

Primary Textbooks and Related Resources

Statistics 145

De Veaux, Richard D., Paul F. Velleman, and David E. Bock. *Intro Stats*. 2nd ed. Boston: Pearson/Addison-Wesley, 2006.

De Veaux, Richard D., Paul F. Velleman, and David E. Bock. *TestGen*. CD-ROM. 2nd ed. Boston: Pearson/Addison-Wesley, 2006. Computerized test bank. Must be used in conjunction with Pearson's TestGen application:
http://wpslive.pearsoncmg.com/wps/media/access/Pearson_Default/720/737317/testgen_login.html.

De Veaux, Richard D., Paul F. Velleman, David E. Bock, and William B. Craine III. *Instructor's Solutions Manual for "Intro Stats."* 2nd ed. Boston: Pearson/Addison-Wesley, 2006.

Miller, Jackie, Richard D. De Veaux, Paul F. Velleman, and David E. Bock. *Printed Test Bank and Resource Guide*. 2nd ed. Boston: Pearson/Addison-Wesley, 2006.

Statistics 245

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. 3rd ed. Belmont, Calif.: Thomson Brooks/Cole, 2008.

Supplementary Textbooks for Reference

Agresti, Alan, and Christine Franklin. *Statistics: The Art and Science of Learning from Data*. Upper Saddle River, N.J.: Prentice Hall, 2007.

Utts, Jessica M., and Robert F. Heckard. *Mind on Statistics*. 3rd ed. Belmont, Calif.: Thomson Brooks/Cole, 2007.

Internet Resources

ARTIST (Assessment Resource Tools for Improving Statistical Thinking). https://app.gen.umn.edu/artist/index.html.
Provides a variety of assessment resources for teaching first courses in statistics.

CAUSEweb.
www.causeweb.org.
Web site for the Consortium for the Advancement of Undergraduate Statistics Education, a national organization whose mission is to support and advance undergraduate statistics education in four target areas: resources, professional development, outreach, and research.

Moore, David S. Statistical Applets for *The Practice of Statistics*, 5th ed.
http://bcs.whfreeman.com/ips5e.
Scroll down to *Student Tools* and click on *Statistical Applets*. (You can also go to www.whfreeman.com, click on *Statistics*, and search for "Moore" to find other texts that may have linked applets.)

StatCrunch: Data Analysis on the Web.
www.statcrunch.com.

Student Activities

The following pages contain two activities that have been developed for Stat 145 and structured with instructions for the teacher. These activities (and others) have been submitted to CAUSEweb (www.causeweb.org) for inclusion in the peer-reviewed activities there. Although these activities and their overviews have not been copyrighted, please give credit to Beau Corkins, Marian Frazier, and Jackie Miller, all of Ohio State University, when using them.

Categorical Data (Chapter 3)

Overview

Objective

We want the students to familiarize themselves with the technology and its use in calculating marginal, conditional, and joint distributions. In addition, students are asked to make conclusions from these tabular and graphical displays. Finally, they are required to come up with their own way (tables, graphs, and so forth) to answer content questions.

The Activity

Prior to the assignment of this activity, students should have received an introduction to graphical displays of quantitative data, contingency (two-way) tables, and joint/marginal/conditional distributions. The data include information on 198 pizza deliveries by various pizza shops in the Ohio State University area. To familiarize them with the technological package they are using, students are first asked to make some simple graphs (bar charts, pie charts) and summarize what they see on these graphs. They are then asked to use multiple graphs to guess which store has the worst on-time record; they use contingency tables to find the conditional distribution and support this guess. Finally, they are asked several questions and not given any clear instructions about how to answer them. In this section, the hope is that students will use what they learned from the first several questions to answer in whatever way (tabular, graphical) makes the most sense to them.

Assessment

The activity is not structured to include any formal assessment. However, assessment can certainly occur through discussion, both classwide and one-on-one. Many of the students' questions will focus on the technology: how to construct different graphs or tables. But if this is the first time students have seen these types of displays, they will also ask more substantive questions about how to interpret the results. Especially with the latter, more open-ended questions, you may need to guide students and remind them of what they were supposed to have learned in the earlier questions. As these questions can be answered in several ways, this may lead to a discussion of the "best" way to approach them.

More formal assessment will generally occur later, in quiz or exam questions. Sample questions include the following:

- Present a graphical display (bar chart, pie chart), and ask students to report some result in context.
- Ask them to calculate the conditional or marginal distribution.
- Given the conditional distribution, are two variables independent?

Teaching Notes

- This activity can be done in class or assigned as out-of-class work. If this is the first time that students are using the technology, we suggest that it be done in class so they can ask questions and collaborate. The activity works extremely well with pairs or groups of three.
- This activity is not dependent on any particular choice of technology. However, students cannot perform the necessary work on their calculators, so they must have access to some statistical computer package.
- The activity takes approximately 40 to 50 minutes, not including a classwide discussion or debriefing session.
- As mentioned above, many of the students' questions will focus on how to use the technology. We recommend letting the students work together to explore the computer package: encourage them to "play around" and find the answer themselves. Of course, the instructor should be available and knowledgeable about the package and how to create every display in the activity.

Student Worksheet with Instructor's Solutions

Introduction

How long did you have to wait the last time you ordered pizza? We all know that there is nothing worse than waiting for a hot, cheesy pizza when you are hungry and trying to get through halftime. So if you want your pizza on time, from whom—and when—should you order? In this activity, we will be using categorical data analysis (including contingency tables, bar charts, and pie charts) to explore which stores have the worst "on-time" record and which days and times are most closely associated with late deliveries.

The Study

The file PIZZA contains data on 198 pizza deliveries collected by students taking an introductory statistics class at Ohio State University in February 2001.

The Variables

Store = name of pizza store

Day of week = day of the week of the order

Distance = distance (miles) from pizza shop to delivery point

Estimate = number of minutes estimated by pizza shop for delivery, or midrange
(for example, if "45–60" was quoted, then used 53)

Time ordered = hour:minutes

Time blocks:

Daytime = pizza ordered noon to 6 p.m.

Dinnertime = pizza ordered 6 p.m. to 8 p.m.

Evening = pizza ordered 8 p.m. to 10 p.m.

Nighttime = pizza ordered 10 p.m. to 3 a.m.

Time arrived = hour:minutes

Delivery time = time arrived minus time ordered (in minutes)

Pizzas = number of pizzas ordered

Other items = indicates if something besides pizza was also ordered (yes/no)

Actual - Estimate = delivery time minus estimate (that is, positive values mean the pizza was late)

±(a-e) = 1 if the pizza was late, −1 if the pizza was early, 0 if the pizza was exactly on time

Questions

[The solutions appear in boldface throughout.]

1. On *StatCrunch*, load the file PIZZA.

2. Create a bar chart of store. What store has the largest proportion of orders on this list?
Papa John's

3. Create a pie chart of the marginal distribution of late status (whether the pizza was early, on time, or late). Are most pizzas early, late, or on time?
The majority of pizzas are early.

4. Open the bar chart (no. 2) and pie chart (no. 3) side-by-side. Notice that by clicking on a section of the pie chart, *StatCrunch* highlights those stores that make up that section. Which two stores appear to have the highest percentages of late pizzas?
Store 1: **Adriatico's**
Store 2: **Pizza Hut**

5. Create a contingency table of store versus late status (whether the pizza was early, on time, or late). Include in this contingency table the values "row percent," "column percent," and "percent of total."

Contingency Table Results

Rows: store

Columns: sign(a−e)

Cell format
Count
(Row percent)
(Column percent)
(Percent of total)

	–1	0	1	Total
Adriatico\'s	7 (35%) (6.25%) (3.535%)	0 (0%) (0%) (0%)	13 (65%) (18.84%) (6.566%)	20 (100.00%) (10.1%) (10.1%)
Ange\'s	0 (0%) (0%) (0%)	2 (100%) (11.76%) (1.01%)	0 (0%) (0%) (0%)	2 (100.00%) (1.01%) (1.01%)
Catfish Biffs	10 (71.43%) (8.929%) (5.051%)	0 (0%) (0%) (0%)	4 (28.57%) (5.797%) (2.02%)	14 (100.00%) (7.071%) (7.071%)
Domino\'s	7 (58.33%) (6.25%) (3.535%)	2 (16.67%) (11.76%) (1.01%)	3 (25%) (4.348%) (1.515%)	12 (100.00%) (6.061%) (6.061%)
Donatos	15 (53.57%) (13.39%) (7.576%)	4 (14.29%) (23.53%) (2.02%)	9 (32.14%) (13.04%) (4.545%)	28 (100.00%) (14.14%) (14.14%)
East of Chicago	5 (55.56%) (4.464%) (2.525%)	0 (0%) (0%) (0%)	4 (44.44%) (5.797%) (2.02%)	9 (100.00%) (4.545%) (4.545%)
Eddy\'s	1 (100%) (0.8929%) (0.5051%)	0 (0%) (0%) (0%)	0 (0%) (0%) (0%)	1 (100.00%) (0.5051%) (0.5051%)
Grandad\'s	1 (100%) (0.8929%) (0.5051%)	0 (0%) (0%) (0%)	0 (0%) (0%) (0%)	1 (100.00%) (0.5051%) (0.5051%)
Gumby\'s	9 (69.23%) (8.036%) (4.545%)	2 (15.38%) (11.76%) (1.01%)	2 (15.38%) (2.899%) (1.01%)	13 (100.00%) (6.566%) (6.566%)
HoundDog\'s	5 (83.33%) (4.464%) (2.525%)	0 (0%) (0%) (0%)	1 (16.67%) (1.449%) (0.5051%)	6 (100.00%) (3.03%) (3.03%)

	–1	0	1	Total
Kings	3 (50%) (2.679%) (1.515%)	1 (16.67%) (5.882%) (0.5051%)	2 (33.33%) (2.899%) (1.01%)	6 (100.00%) (3.03%) (3.03%)
Monkey	4 (66.67%) (3.571%) (2.02%)	0 (0%) (0%) (0%)	2 (33.33%) (2.899%) (1.01%)	6 (100.00%) (3.03%) (3.03%)
Ohio State	2 (100%) (1.786%) (1.01%)	0 (0%) (0%) (0%)	0 (0%) (0%) (0%)	2 (100.00%) (1.01%) (1.01%)
Papa John\'s	33 (60%) (29.46%) (16.67%)	3 (5.455%) (17.65%) (1.515%)	19 (34.55%) (27.54%) (9.596%)	55 (100.00%) (27.78%) (27.78%)
Peppercini\'s	1 (100%) (0.8929%) (0.5051%)	0 (0%) (0%) (0%)	0 (0%) (0%) (0%)	1 (100.00%) (0.5051%) (0.5051%)
Pizza Hut	8 (38.1%) (7.143%) (4.04%)	3 (14.29%) (17.65%) (1.515%)	10 (47.62%) (14.49%) (5.051%)	21 (100.00%) (10.61%) (10.61%)
Rotolo\'s	1 (100%) (0.8929%) (0.5051%)	0 (0%) (0%) (0%)	0 (0%) (0%) (0%)	1 (100.00%) (0.5051%) (0.5051%)
Total	112 (56.57%) (100.00%) (56.57%)	17 (8.586%) (100.00%) (8.586%)	69 (34.85%) (100.00%) (34.85%)	198 (100.00%) (100.00%) (100.00%)

6. Prove your assertion in question 4 by finding the conditional distribution of late status given Store 1 and the conditional distribution of late status given Store 2.

Adriatico's	%
Late	**65%**
On time	**0%**
Early	**35%**

Pizza Hut	%
Late	**47.6%**
On time	**14.3%**
Early	**38.1%**

7. If an ordered pizza is randomly selected, find the probability that it was from Domino's and that it was early.

   3.535%

8. Do time of day and late status appear to be independent? Justify your answer.

   For this, we made a contingency table of time of day versus late status (see below). Although daytime and nighttime have very similar conditional distributions, and dinnertime and evening are similar, the two groups (day/night and dinner/evening) are very different from each other. Based on this, we conclude that time of day and late status are not independent variables.

Contingency Table Results

Rows: time blocks

Columns: sign(a–e)

Cell format
Count (Row percent) (Column percent) (Percent of total)

	Early	On Time	Late	Total
Daytime	15 (45.45%) (13.39%) (7.576%)	1 (3.03%) (5.882%) (0.5051%)	17 (51.52%) (24.64%) (8.586%)	33 (100.00%) (16.67%) (16.67%)
Dinnertime	43 (59.72%) (38.39%) (21.72%)	6 (8.333%) (35.29%) (3.03%)	23 (31.94%) (33.33%) (11.62%)	72 (100.00%) (36.36%) (36.36%)
Evening	36 (63.16%) (32.14%) (18.18%)	9 (15.79%) (52.94%) (4.545%)	12 (21.05%) (17.39%) (6.061%)	57 (100.00%) (28.79%) (28.79%)
Nighttime	18 (50%) (16.07%) (9.091%)	1 (2.778%) (5.882%) (0.5051%)	17 (47.22%) (24.64%) (8.586%)	36 (100.00%) (18.18%) (18.18%)
Total	112 (56.57%) (100.00%) (56.57%)	17 (8.586%) (100.00%) (8.586%)	69 (34.85%) (100.00%) (34.85%)	198 (100.00%) (100.00%) (100.00%)

9. Are pizzas more likely to be late during the week (M–Th) or on the weekend (F–Sun)? Why do you think this is?

   For this, we made a contingency table of day of week versus late status (see below). Looking at row percent, a higher percentage of pizzas are late during the week. Specifically, Tuesday has the highest percentage of late pizzas versus early/on-time ones. Looking at column percent, the highest percentage of late pizzas throughout the week come from weekdays. A possible reason for this is that the pizza places are better staffed on the weekends. They know demand will be high then, so they have a lower percentage of late deliveries.

Contingency Table Results

Rows: day

Columns: sign(a–e)

Cell format
Count
(Row percent)
(Column percent)
(Percent of total)

	Early	On Time	Late	Total
Friday	9 (64.29%) (8.036%) (4.545%)	0 (0%) (0%) (0%)	5 (35.71%) (7.246%) (2.525%)	14 (100.00%) (7.071%) (7.071%)
Monday	20 (55.56%) (17.86%) (10.1%)	4 (11.11%) (23.53%) (2.02%)	12 (33.33%) (17.39%) (6.061%)	36 (100.00%) (18.18%) (18.18%)
Saturday	24 (66.67%) (21.43%) (12.12%)	2 (5.556%) (11.76%) (1.01%)	10 (27.78%) (14.49%) (5.051%)	36 (100.00%) (18.18%) (18.18%)
Sunday	18 (66.67%) (16.07%) (9.091%)	3 (11.11%) (17.65%) (1.515%)	6 (22.22%) (8.696%) (3.03%)	27 (100.00%) (13.64%) (13.64%)
Thursday	15 (51.72%) (13.39%) (7.576%)	2 (6.897%) (11.76%) (1.01%)	12 (41.38%) (17.39%) (6.061%)	29 (100.00%) (14.65%) (14.65%)
Tuesday	8 (30.77%) (7.143%) (4.04%)	5 (19.23%) (29.41%) (2.525%)	13 (50%) (18.84%) (6.566%)	26 (100.00%) (13.13%) (13.13%)
Wednesday	18 (60%) (16.07%) (9.091%)	1 (3.333%) (5.882%) (0.5051%)	11 (36.67%) (15.94%) (5.556%)	30 (100.00%) (15.15%) (15.15%)
Total	112 (56.57%) (100.00%) (56.57%)	17 (8.586%) (100.00%) (8.586%)	69 (34.85%) (100.00%) (34.85%)	198 (100.00%) (100.00%) (100.00%)

Inference for Proportions (Chapters 19 and 20)

Overview

Objective

We want students to practice constructing confidence intervals and performing hypothesis tests. In addition, this activity stresses interpretation of confidence intervals and comparison and application of results in context.

The Activity

Prior to the assignment of this activity, students should have received instruction in sampling distributions and an introduction to constructing confidence intervals for proportions. They should understand the difference between p and $\hat{p}$, although this activity may help them grasp the difference. For the second part of the activity, students should have received an introduction to hypothesis testing. The activity discusses the connection between confidence intervals and hypothesis testing, but it is not necessary that the students see this beforehand.

In this activity, students try to determine whether Mars, Inc., is accurate in its claim that 20 percent of plain M&M's are orange. The data for this activity are collected by students in small groups. Each group takes a sample of M&M's (how many is determined by the class) and counts what percentage are orange. Each group then constructs and interprets its own confidence interval based on that group's sample data. Then they are asked to compare their results (and those of the entire class) to what we expect given Mars's claim.

The second part of the activity explores this question through hypothesis testing. Because this is probably the first activity that students have done with testing, they are taken step-by-step through the process. Again, they interpret their results and compare them to those of the entire class, Mars, and their own results from part 1.

Assessment

The activity is not structured to include any formal assessment. However, assessment can certainly occur through discussion, both classwide and one-on-one. Several parts of this activity lend themselves to discussion. The first section (on checking conditions) is meant as a whole-class discussion and decision-making process. The interpretation of confidence intervals and conclusions from testing will probably lead to spirited exchanges among group members, as will question 5b in part 1. Questions 6 and 7 (part 1) and question 5 (part 2) require the whole class to report and discuss their results and what conclusion they can make about those results.

More formal assessment will generally occur later, in quiz or exam questions. Questions will most likely give students a sample statistic and require them to construct a confidence interval or perform a hypothesis test at some confidence level. Another type of question might identify a confidence level and the results of a hypothesis test and ask students to compare the results or explain how the two are related.

Teaching Notes

- This activity is designed for in-class, group work. It would not be as helpful in an individual, out-of-class situation. The activity works extremely well with several pairs or groups of three.
- This activity is not dependent on any particular choice of technology. In fact, it requires no higher statistical package—all work can be done on a basic calculator, with access to a standard normal table.
- Each part of the activity takes approximately 40 to 50 minutes.
- Several parts of this activity are designed to foster (in fact, require) whole-class discussion. The instructor should encourage (and be prepared for) differences in ideas and opinions. For this reason, time constraints may be an issue; instructors should budget time wisely so that this discussion time does not suffer.

Student Worksheet and Instructor's Solutions

Mars, Inc., claims that its plain M&M's are made up of a certain percentage of orange, blue, green, yellow, red, and brown candies. In this activity, we will explore whether this claim is true.

Part 1: Confidence Intervals

1. How will we sample the M&M's to make sure that all our assumptions/conditions are met?

    a. Plausible independence condition

Because the population of M&M's is so vast, we can assume that our sampling is not imposing any dependence. Our M&M's are from the same bag, however, and that may be a concern with respect to independence.

b. Randomization condition

We must sample in a way that is random: pouring the candies from a bag or using a random dispenser are possibilities.

c. 10 percent condition—is the sample size no more than 10 percent of the population?

Check.

d. Success/failure condition—do we have at least 10 successes and 10 failures?

We must sample enough M&M's to insure that $np > 10$. Because $p = .20$, this means that at least 50 M&M's are necessary. Thus, you might want to put the students in pairs or small groups, in the interest of saving time and money.

Decide, based on these conditions, how we will sample, including how many M&M's per person.

2. Count the number of orange M&M's in your sample: **x**

   If we are interested in the proportion of all M&M's that are orange, what are the parameter, p, and the statistic, $\hat{p}$? What is your value of $\hat{p}$?

   p = proportion of all M&M's that are orange

   $\hat{p}$ = proportion of M&M's in my sample of size *n* that are orange = *x/n*

   Different groups will get different values for $\hat{p}$.

3. Estimate the standard error for your $\hat{p}$. (Hint: Remember the sampling distribution of $\hat{p}$ from chapter 18.)

$$SE(\hat{p}) = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

4. Construct an approximate 68 percent confidence interval and an approximate 95 percent confidence interval for p, the true percentage of M&M's that are orange. Remember to interpret these intervals in context!

   68 percent confidence interval: $\hat{p} \pm 0.994\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$

   95 percent confidence interval: $\hat{p} \pm 1.96\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$

   Interpretation:

   We are 68 percent confident that the true proportion of orange M&M's is between ____ and ____.

   Or:

   If this study was repeated many times, and if each time we randomly drew *x* M&M's, found the proportion of those that were orange, and constructed a 68 percent confidence interval, we would expect approximately 68 percent of those intervals to contain p, the true proportion of orange M&M's. The interpretation for the 95 percent confidence interval should be analogous to that of the 68 percent confidence interval.

5. Mars claims that 20 percent of plain M&M's are orange (http://us.mms.com/us/about/products/milkchocolate/). Did your 68 percent confidence interval contain the $p = 0.2$ figure advertised by the company? Did your 95 percent confidence interval contain this figure?

   a. Based on your intervals, does $p = 0.2$ seem reasonable?

   If their interval contains 0.2, students will certainly say it is reasonable. If the interval does not, they may say that it is reasonable (it almost contains 0.2; this is only one sample) or unreasonable (0.2 is not anywhere near the interval).

   b. How big would your confidence interval have to be so that $p = 0.2$ is within the limits? That is, what is the confidence level of the narrowest interval that still contains 0.2?

   For a given $\hat{p}$:
   Recall that the general form of a confidence interval is
   $$\left(\hat{p} - z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}, \hat{p} + z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}\right).$$
   We want 0.2 to be on the "edge" of this interval. If $0.2 < \hat{p}$, students should set $\hat{p} - z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = 0.2$ and solve for z^*. (If $0.2 > \hat{p}$, set $\hat{p} + z^* \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = 0.2$ and solve for z^*.) This will give the z^* for the narrowest interval that contains 0.2. Then use the standard normal table to find the corresponding confidence level.

6. We will now look at everyone's intervals:

   Talk about why we do this.

   How many (and what percentage) of the classes' intervals include $p = 0.2$? How does this compare with what we expect?

   Of course, we expect 68 percent (95 percent) of the confidence intervals to contain *p*.

   Of the intervals that do not include 0.2, how many are too high (above 0.2)? How many are too low?

   We ask this because it may be that your class has values that are systematically too high or too low, leading to the conclusion (below) that there are more (or less) than 20 percent orange M&M's.

7. Discuss: Do you think that there are, in fact, 20 percent orange M&M's?

   Obviously, this will depend on your classes' results. Things to point out include how many high/low intervals there are (see above), issues with sampling variability, and so forth.

Part 2: Hypothesis Testing

In part 1, we constructed confidence intervals to assess whether we thought Mars was telling the truth about the proportion of orange M&M's. Now we will attempt to answer this same question in another way.

1. How will we check if the facts are consistent with what Mars claims? What parameter are we testing?

   Hypotheses:

   $H_0 : p = 0.2$

   $H_a : p \neq 0.2$

   We have no a priori reason to believe that $p < 0.2$ or $p > 0.2$ specifically, so test the general two-sided alternative.

2. Model:

   What kind of test will we do here?

   Two-sided one-sample proportion.

   Are the appropriate conditions satisfied?

   Plausible independence: As mentioned above, there might be issues with this. Proceed with caution.

   Randomization: We tried to achieve this through our sampling method.

   Success/failure: It is hoped that all students had (at least) 10 orange M&M's in their samples (assuming samples of size 50).

   10%: *n* is certainly less than the entire population of M&M's.

   What is our null model?

   The sampling distribution of $\hat{p}$ **is Normal with mean =** $p = 0.2$ **and st.dev. =** $\sqrt{\frac{p(1-p)}{n}} = \sqrt{\frac{0.02(0.98)}{n}}$**. Remember to stress that in a hypothesis test, we assume** H_0 **is true.**

3. Mechanics:

   You want to compare your data to what we would expect if the null model were true. Thus, your z value is . . .

   $$z = \frac{\hat{p} - 0.2}{\sqrt{\frac{0.02(0.98)}{n}}}$$

   . . . and your *P*-value is . . .

   ***P*-value =** $2P(Z > |z|)$

4. . . . which leads you to conclude . . .

   Talk about what α level they compared this to. *Do not* institute a mindless $\mu = 0.05$ **rule with no justification!**

5. Discuss: Does this agree with what you decided in part 1 about Mars's claim? What about everyone else? How many of your classmates rejected the null hypothesis?

   Here, have them look at whether they reached the same conclusion as in part 1. This should lead to a discussion of the relationship between confidence intervals and hypothesis testing. The number who rejected here should be (almost) the same as those who had intervals not containing 0.2.

Sample Syllabus 3

Michael Allwood
Brunswick School
Greenwich, Connecticut

School Profile

Location and Environment: Brunswick is a pre-K–12 boys' private day school in Greenwich, a town at the southwestern tip of Connecticut. Brunswick's Upper School (grades 9–12) has a coordinated arrangement with Greenwich Academy, the girls' private school located close by, and the boys and girls take academic courses on both campuses. Thus, the high school boys interact with the girls in academic, artistic, and social contexts, with the rest of their school life (student governments, athletics, publications) being a single-sex experience. The schools' mathematics departments, however, have opted to work separately, based on research that has shown that girls learn mathematics more effectively in a single-sex environment.

Brunswick parents take a strong interest in their sons' education, so we are lucky to have students who are willing to work very hard for academic success. Consequently, the school's college record is impressive, with all of our students attending college and nearly 90 percent of our graduates going on to schools designated by Barron's Educational Series as "highly competitive" or "most competitive."

Grades: Prekindergarten–12

Type: College-preparatory boys' day school

Total Enrollment: 884

Ethnic Diversity: African American, 4.7 percent; Hispanic/Latino, 3.4 percent; Asian American, 3.3 percent; Middle Eastern American, 0.7 percent; Native American, 0.1 percent; multiracial, 3.0 percent.

College Record: All of our graduates go on to four-year colleges.

Personal Philosophy

Most of the students who take AP Statistics at Brunswick do so because they like math, and teaching the course gives me the opportunity to show how mathematics and mathematical thinking can be applied to important real-life situations. The AP Statistics Exam requires of the student a true understanding of the material included in the course, and 75 percent of its content is descriptive and/or interpretative. In recognition of this, I encourage in-depth discussion of the concepts underlying statistical thinking and of the process of applying these ideas to the everyday issues that are raised in class. Some of the more complex principles are clarified by means of classroom activities, and throughout the course I emphasize the need for written explanations that employ correct use of terminology and that are clear, precise, and concise.

Class Profile

Each year the school offers either one or two sections of AP Statistics, depending on the number of students choosing the course. When we have had two sections, the two teachers have followed the same curriculum and given the same tests. Currently, we have one section of 15 students. Generally, we prefer that students take AP Statistics only as a *second* math course, and those who enroll in this class must have previously taken, or concurrently be taking, Precalculus. All students in the course take the AP Exam.

Brunswick's Upper School operates on a seven-day rotating schedule, in which each class meets for an hour on five school days in every seven. The school's academic year runs from September to June and is 33 weeks long, exclusive of breaks and holidays. It is divided into four quarters, with a midyear exam at the end of the first semester. AP math classes do not meet after the AP Exams.

Course Overview

The topics are largely organized in the order in which they are presented in the textbook, with the main exceptions being that the data collection unit is left until after bivariate data, and errors in hypothesis testing and regression are left until the end of the course. Each student owns a TI-83 Plus or TI-84 calculator. A TI viewscreen with overhead projector is used in class (usually operated by a student). Students are given a copy of the formula sheet used in the AP Exam at the start of the course. Copies of this sheet are also provided during the tests.

Course Objectives

My aim is that students finishing the course should have attained the following competencies:

- Know the facts and have the skills required by the *AP Statistics Course Description*
- Have an intuitive understanding of the background of these facts and skills
- Be able to explain and interpret statistical concepts with clear and refined use of language
- Have gained experience in the application of statistical ideas to real-life situations
- Have developed an appreciation for the relevance and significance of statistics in the real world

Texts

Our primary text is the second edition of *Introduction to Statistics and Data Analysis* by Peck, Olsen, and Devore. We also use the second edition of *The Practice of Statistics* by Yates, Moore, and Starnes. (See the Teacher Resources section in this syllabus for full citations.)

Course Planner

Please note the following:

- The timetable below represents the plan for a typical year. In any given year, it must always be adapted according to the needs of the students, interruptions to the schedule, and so forth.
- Possible examples and exercises from the textbook that might be used in each class or homework assignment are listed in brackets at the end of each entry. "Ex." refers to a worked example from the textbook, in which the authors have provided a solution to the problem. "Made-up exs." refers to times when data from students are used, when data from a previous example are used to demonstrate a new concept, or when numbers are generated on the spot. Items that are not preceded by any abbreviation indicate an exercise from one of the textbook's problem sets.
- The following abbreviations are used to indicate source material: POD = Peck, Olsen, Devore, *Introduction to Statistics and Data Analysis*; YMS = Yates, Moore, and Starnes, *The Practice of Statistics*.

Semester One

UNIT I: DATA SUMMARY AND DISPLAY

Class 1

(Some of Unit I is included in the previous year's math course, so these items can be covered quickly.) Stem-and-leaf displays; shapes of distributions; relationship of shape of stem-and-leaf display to pattern in dotplot; mention of "splitting stems" in stem-and-leaf display; median and quartiles, interquartile range (percentiles); "middle 50 percent" [Ex. 3.10, Ex. 3.15 (draw stemplot), 3.18 (adapted), made-up exs.]

Class 2

Use of calculator to find five-number summary; boxplots; parallel boxplots; comparing distributions [3.22 (adapted), 3.62, 4.34 (adapted), made-up exs.; and the main exercise from "Matching Plots to Variables," in Scheaffer et al., *Activity-Based Statistics*, p. 15]

> AP tip: Comparing distributions is very important for the AP Exam: see the exam scoring guidelines for details—e.g., 2005, free-response question no. 1(a).

Class 3

Outliers; outliers on calculator (modified boxplot); mean, variance, standard deviation; mean, variance, standard deviation of frequency distribution; mean, variance, and standard deviation (including frequency distributions) on calculator [3.28 (adapted), 3.32 (adapted), 4.37 (adapted), made-up exs.]

Class 4

Mean versus median and implication of skewness; sensitivity of mean and standard deviation to extreme values; criteria for appropriateness of use of mean and standard deviation; discrete versus continuous data; histograms; z-scores [3.28, 3.26, Ex. 4.19, 4.43, made-up exs.]

UNIT II: BIVARIATE DATA

Class 5

Scatterplots and correlation in general; drawing scatterplot on calculator and commenting; calculation of correlation using calculator; range of values of correlation; correlation formula [5.6 (adapted), 5.12, 5.16, made-up exs.]

Class 6

Test on Unit I

Class 7

Correlation: explanation of invariance under addition of a constant to all x- (or y-) values and under multiplication of all x- (or y-) values by a constant; correlation versus causation; interpretation of correlation value; introduction to regression; use of the calculator to find the equation of the regression line and draw on graph [5.9, 5.12, 5.17, made-up exs.]

> AP tip: The interpretation of the value of the correlation is very important for the AP Exam: see the exam scoring guidelines for details—e.g., 2002, free-response question no. 4.

Class 8

Definition of regression line in terms of least squares; least-squares activity (see the Student Activities section in this syllabus for details); formulas for slope and y-intercept; how to state the equation of the regression line [5.19, 5.21]

> AP tip: When stating the equation of the regression line, AP Exam questions require definition of any variables used, along with the word "predicted" applied to the y-variable.

Class 9

Interpretation of slope and y-intercept of the regression line; extrapolation; outliers in bivariate context; influential points; calculator demonstration for influential points (see "Calculator Demonstrations" in my Student Activities section for details) [5.34, 5.36, Ex. 5.10 (adapted)]

AP tip: Correct interpretation of the slope and y-intercept of the regression line are important for the AP Exam: see exam scoring guidelines for details—e.g., 1999, free-response question no. 1.

Class 10

Use of residual plot to show if a straight line is the best model; sum of squares of residuals and its relevance; calculator demonstration for residual plots (see "Calculator Demonstrations" in my Student Activities section for details); introduction to coefficient of determination [5.32, 5.33, made-up exs.]

Class 11

Coefficient of determination, r^2; reading computer displays in bivariate context; calculation of b, a, and r without statistical features of the calculator; equation on formula sheet relating b and r [5.41, 5.42, made-up exs.]

The coefficient of determination: This is one of the trickiest concepts in the course. I have found it best to explain the idea in the following way: When all the points lie on a straight line, there is some variability in the y-values but it is all "explained by" the x variable (if I know the x value, I know the y value exactly); one y value is higher than another because the associated x value is higher (positive association). When the points are moved off the line, there is *unexplained* variability in the y-values. In this second situation, some of the variability in the y-values can be attributed to variation of y with x according to the line (as in the first situation), and the remainder can be attributed to the fact that the points are not on the line. The proportion of the y-variability that is explained by "the variation of y with x according to the line" is r^2. When points are close to the line, the unexplained variability is low. When points are far from the line, the line has low predictive ability.

UNIT III: COLLECTING DATA (1)

Class 12

Difference between observational study and experiment; limitation of observational study; confounding variables [2.27, 2.28, 2.35, 2.36, 2.37]

Class 13

Test on Unit II

Class 14

Simple experimental concepts: population; use of volunteers; randomization (and why); control group and its purpose; generalization; replication; direct control [2.28, 2.30, 2.44, 2.48a–e]

Class 15

Placebo effect; use of placebo; blinding (single and double); how to randomize [2.54, 2.57 (adapted)]

AP tip: In AP Exam free-response questions on experimental design, students are required to include a description of *how* the treatments are randomized—e.g., 2006, question no. 5(b).

Class 16

Blocking; summary of experimental design [2.40, 2.43, 2.45]

Blocking: This should be explained in terms of reduction of variability in order to more easily discern the effect of the explanatory variable. For further explanation, see YMS, p. 303.

Class 17
PBS video: *The Wonder Pill* (about the placebo effect)

UNIT IV: COLLECTING DATA (2) / PROBABILITY (1)

Class 18
Census; simple random sample (SRS); stratified sample; cluster sample; systematic sample; convenience sample [2.6, 2.8, 2.11a–d]

Class 19
Test on Unit III

Class 20
Bias in general; selection bias; response bias; measurement bias; nonresponse bias (note that small sample size is not a source of bias) [2.16, 2.17, 2.25]

Class 21
Probability using Venn diagrams; probability notation involving unions, intersections, complements; "addition rule" [sheet of problems]

Probability: This topic is covered in considerable detail in the textbook, but in order to allow time for the remainder of the course, I have found it necessary to condense my approach. The order of subtopics given here is the one I have found to be most efficient.

Class 22
Mutually exclusive events; conditional probability [sheet continued]

Class 23
Review and extension of conditional probability; definition and explanation of independent events [6.39c, 6.49, made-up exs.]

Class 24
Problems involving independent events; probability of "at least one" [6.47, 6.48 (adapted), 6.50]

UNIT V: PROBABILITY (2) / RANDOM VARIABLES

Class 25
Tree diagrams [made-up exs.]

Class 26
Test on Unit IV

[*End of First Quarter*]

Class 27
Tree diagrams continued; Bayes' rule [6.71, 6.72, 6.73]

Bayes' rule: For this I follow the method essentially as given on p. 323. I omit the formula given on p. 324.

Class 28
Random variables; discrete versus continuous; probability distributions; graphical representation [7.11, 7.12, 7.14, 7.16, 7.18]

Class 29
Continuous random variables; probability density functions [7.23, 7.24, 7.26]

Class 30
Mean, variance, and standard deviation of discrete random variable; formulas for expected value and variance of $aX + b$ [7.29, 7.33, 7.40]

UNIT VI: BINOMIAL AND GEOMETRIC DISTRIBUTIONS

Class 31
Binomial distribution [made-up exs.]

Class 32
Test on Unit V

Class 33
Binomial distribution continued; use of “binompdf” and “binomcdf” on calculator [7.46, 7.49, 7.55a–b]

Binomial probabilities: In order to familiarize students with the basic binomial probability formula, I assign problems in which use of “binompdf” or “binomcdf” is not allowed.

Class 34
Mean and standard deviation of binomial distribution; geometric distribution; introduction to normal distribution (intuitive only) [7.54, 7.55c–d, 7.62, made-up exs.]

Distinguishing distributions: The Unit VI test includes a question that requires students to differentiate between random variables that are binomially distributed, geometrically distributed, normally distributed, or none of these.

Class 35
Test on Unit VI

UNIT VII: NORMAL DISTRIBUTION / MEAN AND VARIANCE FORMULAS

Class 36
Normal distribution problems: finding probabilities and the inverse normal function [7.73a–d, 7.77, 7.78]

Class 37
Normal distribution problems: finding mean and/or standard deviation [sheet of problems]

Class 38
Review of mean, variance, and standard deviation of $aX + b$; mean, variance, and standard deviation of $X + Y$; mean, variance, and standard deviation of $aX + bY$ [made-up exs.]

Class 39
Sums and differences of independent normally distributed random variables; conditional probability problems involving normal distribution [sheet of problems]

UNIT VIII: SAMPLING DISTRIBUTIONS / DISTRIBUTION OF SAMPLE MEAN

Class 40
Overview of population parameters, sample statistics, and the use of a statistic to estimate a parameter

Class 41
Test on Unit VII

Class 42
German tanks activity (see my Student Activities section for details)

Class 43
Sampling distributions; unbiased statistics; use of standard deviation to compare statistics [8.4, 8.6, 8.9]

Class 44
Distribution of sample mean; central limit theorem [8.20, 8.21, 8.24]

Class 45
Central limit theorem activity (see my Student Activities section for details)

Class 46
Test on Unit VIII

Classes 47–52
Review for midyear exam, which is administered outside of class (see the Teaching Strategies section that follows this Course Planner for details)

[*End of Second Quarter*]

Semester Two

UNIT IX: SIMULATION / INFERENCE (1)

Class 53
Simulation activity (see my Student Activities section for details)

Class 54
Simulation [sheet of problems]

Class 55
Normal approximation to binomial distribution; calculator demonstration (see "Calculator Demonstrations" in my Student Activities section); distribution of a sample proportion [8.32, 8.34, 8.35]

Class 56
Confidence interval for a population proportion; "margin of error"; interpretation of confidence interval and of confidence level [9.15, 9.23, 9.25]

> Confidence intervals: The idea of a confidence interval is tricky for students. They need to understand that it is the set of *fixed* parameter values that make feasible the sample results obtained.
> AP tip: When a confidence interval is asked for in an AP Exam free-response question, students are required to: (a) test the conditions for the process; (b) find the confidence limits using the appropriate formula; and (c) interpret the interval in the context of the problem. While it is not always required, students should also be able to write a coherent interpretation of the confidence level.

UNIT X: INFERENCE (2)

Class 57
Confidence interval for population mean; normal and t distributions [9.35a–b, 9.38, 9.43]

Class 58
Test on Unit IX

Class 59
Hypothesis test for population proportion; one-tail and two-tail [10.27, 10.28, 10.29]
AP tip: In any hypothesis test in an AP Exam free-response question, students are required to: (a) state the hypotheses, defining any symbols used for the population parameters; (b) test the conditions for the procedure to be used; (c) evaluate a test statistic using the correct formula and find the *P*-value; and (d) reach a conclusion in the context of the problem, linking this conclusion with the *P*-value. (Procedures involving critical values of the test statistic rather than *P*-values are also acceptable.)

Class 60
Hypothesis test for population mean: *z* and *t* tests [10.48, 10.49 (adapted), 10.57, 10.58]
AP tip: When the question does not state that the population(s) is/are normally distributed, where the sample size(s) is/are not large, and where data *values* are given (as opposed to summary values such as sample mean and standard deviation), it is necessary for students to check that the sample values make reasonable the assumption that the population(s) is/are normally distributed. This involves drawing, for example, a dotplot or boxplot and observing that the sample values show a distribution that is roughly symmetric and includes no outliers.

Class 61
z and *t* tests for difference of population means (*t* test: only unpooled version) [11.24, 11.25, 11.26]

Class 62
Confidence interval for difference of two population means; review of confidence interval ideas in general [11.12a, 11.18c]

UNIT XI: INFERENCE (3)

Class 63
Introduction to distribution of difference of two sample proportions

Class 64
Test on Unit X

Class 65
Hypothesis test for difference of two proportions; confidence interval for difference of two proportions; relevance of confidence interval containing zero [11.54, 11.55, 11.56]

Class 66
Paired *t* test [11.32, 11.36, 11.39]

Class 67
Distinguishing between paired and two-sample *t* tests; paired and two-sample *t* confidence intervals [11.38a, 11.72, 11.80]

UNIT XII: INFERENCE (4)

Class 68
Confidence intervals: required sample size for given margin of error [9.27, 9.46, 9.47]

Class 69
Test on Unit XI

Class 70
Chi-square test for goodness of fit [12.7, 12.8, 12.9]
Calculator tip: The calculator's lists can be used in an ingenious way to find the value of the test statistic and the *P*-value: see YMS, p. 734, or POD, p. 670.

Class 71
Chi-square test for independence [12.20, 12.21]
Calculator tip: The chi-square test on the "Stat, Tests" menu evaluates the expected frequencies: see POD, p. 673, or YMS, p. 754.

Class 72
Chi-square test for homogeneity; distinguishing between three types of chi-square test; inference activity (see my Student Activities section for details) [12.16, 12.28, 12.36, 12.40, 12.42]

Classes 73 and 74
Inference activity continued

UNIT XIII: ERRORS IN HYPOTHESIS TESTING

Class 75
Introduction to Type I and II errors

Class 76
Test on Unit XII

[*End of Third Quarter*]

Class 77
Errors: problems involving description of Type I and II errors and their consequences [10.14, 10.17, 10.19]

Class 78
Discussion of effect on probability of Type I and II errors (and power) by changes in significance level and sample size (and true value of parameter) [10.16, 10.20, 10.21]

Class 79
Quiz on Unit XIII

UNIT XIV: INFERENCE FOR REGRESSION / NONLINEAR REGRESSION

Class 80
t test for closeness to linear relationship (done on calculator) [13.21a–b, 13.25]

Class 81
Confidence interval for slope of the regression line (and hypothesis test) by use of computer read-out and by use of formula for s_b given on the formula sheet [13.18a, 13.20 (adapted), 13.21 (adapted), 13.24b]

Class 82
Nonlinear regression: finding the best transformation by trial and error; prediction [sheet of problems]

Class 83
Nonlinear regression: use of residual plot; logarithmic transformations; implication of straight-line logarithmic relationship in terms of original relationship [sheet continued]

Class 84
Exponential and power relationships; prediction [sheet continued]

Class 85
Review and consolidation of Unit XIV

Class 86
Test on Unit XIV

Class 87
Cumulative relative frequency graphs; other minor topics missed during the year [Ex. 3.16, handout]

Classes 88–94
Review for the AP Exam (see the Teaching Strategies section below for details)

[*End of Fourth Quarter*]

Teaching Strategies

A typical class begins with a quick verbal check to make sure that everyone has completed the previous night's homework. I then run through the answers to that assignment, very often choosing students randomly to read out their written explanations. (This method serves as excellent preparation for the AP Exam, because students have an opportunity, on a daily basis, to think critically about their own and their peers' wording of statistical concepts.) Next, I introduce the main item of work to be explored in that class, using data collected from the class or by means of an example from the textbook. I always encourage discussion so that a real appreciation for the relevance and the essence of the topic is established. If mathematical derivation of a formula is required, that work is also done at this stage. I then give the students a further example to solve in class by themselves, or, if time is short, we discuss an example as a class, talking about how each part of the problem should be tackled. Finally, I assign the next day's homework.

Most of the time, I either stand at the front of the room, using the whiteboard and/or leading class discussion, or the students work on brief (ungraded) practice assignments, discussing their findings with their neighbors as necessary. In the first of these two modalities, there is extensive questioning—by me, in order to encourage constructive and critical thought, and by the students, when clarification is needed. Occasionally, in the context of project work, students use class time for data collection and later present the results of their work to the rest of the class. The TI-83 (or -84) calculator is used extensively throughout the course for calculation, graphical representation of data sets, and demonstration of concepts.

Throughout the course, test questions and review examples are designed to mimic the style of AP Exam free-response questions, and the questions are graded according to criteria similar to those used for the AP Exam. In order to encourage familiarity with the definitions and formulas involved, I often ask students to do calculations without using the statistical features of the calculator. Prior to each test, I hand out a set of review questions (usually the test questions from the previous year), and the students are required to complete this for the class *before* the class on which the test is scheduled. When we then go over this assignment in detail, they gain a good understanding of the test requirements and have the opportunity to ask questions about items that may still confuse them. The remainder of that class is used to begin the next unit of material.

For approaches to teaching specific topics, see the "AP tips" and other underlined suggestions and recommendations throughout the Course Planner above. Much of the learning that goes on in my classroom is based on the students' working through designated problems and examples during the class period, as noted in the daily schedule. Detailed descriptions of many of these exercises can be found in the Student Activities section that begins on page 99.

Review for the Midyear Exam

The material studied in the first semester is condensed into six major topic areas, and one of these is covered in each of the six review classes and the associated homework by means of multiple-choice questions from *Barron's AP Statistics*. Additionally, the first homework assignment in the review process is to read the "Planning a Study" section in that book in order to reinforce understanding of the topic, introduce students to further terminology, and provide a more detailed look at matched pairs design.

Review for the AP Exam

This process consists of the following:

- AP Exam free-response questions are assigned as graded homework.
- AP Exam multiple-choice questions from the Released Exams are assigned as graded homework or done in class.
- AP Exam free-response questions are done in class and graded by peers according to published scoring guidelines.
- A summary of inference and a sheet of mixed inference questions are distributed.
- A summary of computer readouts encountered during the year is distributed.
- A sheet of AP Statistics Exam tips for students (from AP Central) is distributed.

A word of advice to new teachers of AP Statistics: work through a variety of past AP Exam free-response questions *yourself*, and grade your own answers according to the official scoring guidelines. Through this experience, you will often find that you have neglected to mention certain critical details—and when it comes to the exam, students benefit hugely from a teacher who is familiar at this level with the specifics of what is required.

Student Evaluation

In the first three quarters, grades are based entirely on the students' test scores. This is possibly unusual and therefore deserves some explanation. First, all the students almost invariably do their nightly homework assignments without the incentive of grades, and I further encourage full completion of this work by the random selection of students to read out their written explanations. Second, I have found over the years that projects and activities turn out to be more effective if they are not graded. The difference has, in fact, been marked, with graded projects provoking a great deal of worry about the grading requirements, whereas ungraded projects have been done thoughtfully and with enthusiasm. Third, owing to their academic, athletic, and artistic commitments, our students tend to be under considerable time pressure. Therefore, while retaining the aim for very high levels of achievement in the subject, I look for every opportunity to reduce the demands put on the students by this, their second math course.

Students take approximately four tests in each of the first three quarters. In the fourth quarter, I give one test and one quiz, followed by several graded homework assignments consisting of past AP Exam questions. In the fourth quarter, the graded homework assignments count for 60 percent of students' grades, with the remaining 40 percent coming from the test and the quiz.

Each of the first two quarters counts as 36 percent of the first semester grade. The midyear exam accounts for the remaining 28 percent. In the second semester, the grade is formed by an average of the third- and fourth-quarter grades. The course grade is the average of the first and second semesters.

Brunswick School's grading scale is as follows:

A+	98–100 percent
A	93–97 percent
A–	90–92 percent
B+	87–89 percent
B	83–86 percent
B–	80–82 percent
C+	77–79 percent
C	73–76 percent
C–	70–72 percent
D+	67–69 percent
D	63–66 percent
D–	0–62 percent

Teacher Resources

Primary Textbook

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. 2nd ed. Belmont, Calif.: Thomson Brooks/Cole, 2005.

Other Books and Articles

Allwood, T. Michael M. "A Statistical Supplement: The Formulas Explained." In *Teachers' Resource Binder for "Introduction to Statistics and Data Analysis," 2nd ed.* Belmont, Calif.: Thomson Brooks/Cole, 2005.

Bock, David E., Paul F. Velleman, and Richard D. De Veaux. *Stats: Modeling the World*. Boston: Pearson/Addison-Wesley, 2004.

College Board. 2002 *AP Statistics Released Exam*. New York: College Board, 2002. (Note: The 2007 Released Exam has become available since this syllabus was submitted.)

Dinkheller, Ann L., and David C. Flaspohler. "German Tanks: A Problem in Estimation." *Mathematics Teacher* 92 (November 1999): 724-28.

Hugill, Michael. *Advanced Statistics*. London: Bell and Hyman, 1985.

Mann, Prem S. *Introductory Statistics*. 3rd ed. New York: Wiley, 1998.

Sternstein, Martin. *Barron's AP Statistics: How to Prepare for the Advanced Placement Exam*. 3rd ed. Hauppauge, N.Y.: Barron's Educational Series, 2004.

Yates, Daniel S., David S. Moore, and Daren S. Starnes. *The Practice of Statistics: TI-83/89 Graphing Calculator Enhanced*. 2nd ed. New York: W. H. Freeman, 2003.

Web/Video

AP Central.
apcentral.collegeboard.com.
I use this Web site for AP Exam free-response questions, scoring guidelines, and advice for students.

Scientific American Frontiers: The Wonder Pill. 2003. Hosted by Alan Alda. Distributed by PBS Home Video. VHS. 60 minutes.
www.shoppbs.org.

Student Activities

Least Squares (Class 8)

Students are given graph paper and a set of about six points. Each student plots the points and then draws a line in an attempt to minimize the sum of the squares of the vertical distances of the points from the line. The sums of squares are collected and compared with the result for the true regression line produced by a calculator. This last calculation is done by sum(LRESID^2). You can also ask students to draw a "good line" and ask how they will compare the lines to motivate the least-squares criteria.

German Tanks (Class 42)

This is an introduction to parameters, statistics, estimation, and sampling distributions and simulates a situation that occurred in World War II, in which Allied statisticians estimated the total number of German tanks by using the serial numbers of captured tanks. A bag contains cards that are numbered consecutively 1 to N (N can be about 300). Each group of students takes a random sample of seven cards and formulates and evaluates a statistic to estimate N. The relative merits of the statistics are discussed. The statistic used in World War II is then given: $(M–1)(n+1)/n$, where M is the maximum "serial number" in the sample and n is the sample size (here $n = 7$). The most-favored student statistic and this statistic are evaluated for each of the samples and compared. Finally, the true value of N is given. (The idea for this activity was discussed in the National Council of Teachers of Mathematics's *Mathematics Teacher* in November 1999. The activity is also included in *Activity-Based Statistics*. My version is significantly different.)

Central Limit Theorem (Class 45)

Each student seeds the random number generator on his calculator by storing his own chosen number to "rand," clears all lists in the STAT editor, then proceeds through the following steps, guided by me:

1. Make a "population" of size 100 by 1/1000seq(X^2, X,1,100)→L_1.

2. Use a histogram to show the shape of this highly skewed population distribution.

3. 0→N.

4. N+1→N:L_1(randInt(1,100))→L_2(N):N ENTER, ENTER,… This repeatedly samples numbers randomly from the "population" and enters them in L_2, displaying the value of the counter, N, after each sampling. Stop when N = 40.

5. Use 1-Var Stats L_2 to find the sample mean. Type this sample mean into L_3.

6. Repeat from step 3, recording as many sample means in L_3 as time permits.

7. Link cords are then used to gather all the sample means as a list on the overhead calculator. A histogram of the sample means is displayed and compared with the appropriate normal distribution.

Simulation (Class 53)

I have used various different activities for this topic. Here is one example:

1. The teacher writes four simple negative emotions on the board (e.g., anger, guilt, loneliness, disappointment).

2. A student volunteer is chosen.

3. For each emotion, the volunteer thinks of an occasion when he has felt that emotion.

4. The volunteer numbers the emotions 1–4 and (privately) uses RandInt(1,4) on his calculator to choose one of the emotions. He then sits in front of the class thinking intently of the occasion on which he felt that emotion (not *acting* the emotion).

5. The rest of the students in the class try to "pick up" which emotion is being felt by the volunteer, and they write down their decisions.

6. The number of correct decisions is counted.

A simulation is then carried out in order to discover whether the result achieved is significant or, if not, what results could be considered significant. This is done as follows:

7. Suppose there are 14 members of the class, excluding the volunteer. The teacher demonstrates the simulation of one set of 14 random guesses by using RandInt(1,4,14) and counting the number of correct "responses."

8. Each student seeds the random number generator on his calculator by storing his own chosen number to "rand."

9. The students repeat the process in step 7 as many times as possible.

10. A frequency distribution for the numbers of correct responses over all the runs of the simulation is established on the board at the front of the class.

11. Using the frequency distribution, the significance of the result achieved (in step 6) and/or a critical region for the number of correct responses can be established.

12. If there is time, a comparison can be made between the frequencies achieved in the runs of the simulation and the frequencies predicted by the binomial distribution.

Inference Activity (Classes 72–74)

In class 72, the class is divided into groups of three or four. Each group decides on a hypothesis to be tested and what data will be collected to test the hypothesis. (Data are to be collected by means of a survey or an experiment, not by means of published information. Poor sampling methods are tolerated as long as the limitations are realized by the students.) For homework after class 72 and during class 73, the data are collected. For homework after class 73, the data are analyzed by means of the appropriate hypothesis test. In class 74, each group presents its results to the rest of the class, and discussion of, for example, the appropriateness of the sampling methods and the applicability of the hypothesis test is encouraged.

Calculator Demonstrations

Influential Points (Class 9)

This is to show that influential points tend to have extreme x values. Create a cluster of points with negative correlation by seq(X,X,0,5,0.1)→L_1, 5−0.5L_1+randNorm(0,0.5,51)→L_2. With a [0,20] by [0,20] window, make a scatterplot with xlist=L_1 and ylist=L_2. Draw the regression line for this set. Show that adding the point (2.5,15) has little effect on the regression line, whereas adding (12,5) has a large effect.

Residual Plots (Class 10)

This shows how the residual plot can reveal a curved pattern in what initially seems to be a linear relationship. First enter seq(X,X,20,30,1)→L_1 and √(10+L_1^2)+randNorm(0,.002,11)→L_2. A scatterplot of L_1 against L_2 shows what appears to be a straight line, but a residual plot shows that a curve would provide a better fit. Point out that the r value for the original set is close to 1, but this does *not* mean that a straight line is the best fit.

Normal Approximation to Binomial Distribution (Class 55)

This is to demonstrate that the binomial distribution B(40, 0.6) is closely approximated by the normal distribution N(40·0.6, √(40·0.6·0.4)). Follow these steps:

1. seq(X,X,0,40)→L_1. (This stores the integers 0,1,…,40 in L_1.)
2. binompdf(40,.6) →L_2. (This stores the probabilities for $B(40, 0.6)$ in L_2.)
3. Using STAT PLOT, switch Plot 1 on as a histogram with Llist: L_1 and Freq: L_2.
4. Set up a window of [14.5, 34.5] by [0.5, 1.5] with Xscl = 1.
5. Using the "Y=" key, delete any functions that have been entered and make sure that only Plot 1 is on.
6. By pressing the GRAPH key, the histogram of $B(40, 0.6)$ is displayed.
7. For the function Y_1, enter normalpdf(X,40*.6,√(40*.6*.4)).
8. Move the cursor to the left of "Y_1" and select the "path" graph style (the fifth option).
9. Again press GRAPH and watch the normal distribution curve being superimposed on the histogram.

Sample Syllabus 4

Anne M. Carroll
Kennett High School
Kennett Square, Pennsylvania

School Profile

Location and Environment: Kennett High School serves a diverse rural and suburban populace in southern Chester County in the southeastern corner of Pennsylvania, close to the borders of Delaware and Maryland. The cornerstone of our school was laid during the Great Depression in the 1930s. Located in the historic borough of Kennett Square, a small town with a population of about 5,300, this recently renovated school was the original single building of the Kennett Consolidated School District. In addition to the high school, the district now consists of three elementary schools and one middle school spread over several townships.

The area is a bedroom community for Wilmington, Delaware, with many parents employed by DuPont and other chemical and pharmaceutical giants. Moreover, the greater Kennett area continues to provide a large base of agricultural workers for the mushroom industry: Kennett Square is known as the mushroom capital of the world. Large numbers of immigrants from Mexico provide the workforce for the agricultural trade, and the transience of this population is a challenge to the educational system. Many households are monolingual, and older students often come to the high school after not being in classes for many years. Approximately 28 percent of the district population is eligible for free or reduced-fee lunches.

Grades: 9–12

Type: Public high school

Total Enrollment: 1,212

Ethnic Diversity: Hispanic/Latino, 32 percent; African American, 5 percent; Asian American, 1 percent.

College Record: Of our graduates, 69 percent go on to four-year colleges; 17 percent choose junior colleges, community colleges, or technical schools; and 2 percent join the military.

Personal Philosophy

An understanding of statistics is necessary for anyone to be a savvy consumer, an informed citizen of a democracy, and a successful student of many other disciplines. The AP Statistics course gives students an opportunity to build a deep conceptual understanding of graphical analysis and statistical inference and their roles in decision making. This course is the one that I wish that I had taken before the calculus-based statistics I had at both the undergraduate and graduate mathematics levels. Students who take this course are able to read information critically and to pursue further statistical studies, and I am gratified to be a part of helping them to achieve these skills.

Class Profile

Traditionally, Kennett High School has offered one section of AP Statistics with an enrollment of between 5 and 20 students, according to demand. We also offer a less demanding course called Applications of Algebra/Statistics that includes one semester of statistics (the other semester is a review of Algebra 2 topics and forms with emphasis on problem solving), as well as a stand-alone semester statistics course. The AP course meets on a traditional schedule, five days a week for one period in an eight-period day. Classes are 42 minutes long. The year is divided into two semesters, each having two marking periods. The first semester concludes with a required midterm examination. All AP students are required to take the AP Exam. Having done so, they are exempt from the second-semester examination. The course is available to any student who has successfully completed Algebra 2 and who has either completed or is concurrently enrolled in Analysis (Precalculus). Generally, students taking AP Statistics are juniors or seniors (although sophomores have taken the course).

Course Overview

The basic textbook used for this class is *The Practice of Statistics* (second edition) by Yates, Moore, and Starnes, hereafter referred to as YMS. (See the Teacher Resources section of this syllabus for a full citation.)

The major features of the course can be summarized as follows:

<u>Expectations</u>

This is a college-level class that moves at a fast pace. There is time for fun but no time for nonsense. It is assumed that all students will show respect for themselves, for their peers, for the teacher, and for any guests.

<u>Attendance</u>

Class attendance is essential to a student's success in this course, where each day builds on the previous day's learning. Work missed because of class absence owing to illness or other excused reason must be made up within the number of days missed. Any unexcused class absence results in no credit for the day's work.

<u>Participation</u>

Each student must participate in class. Participation includes bringing the necessary materials; preparation (having homework, both written and study, complete); asking questions for clarification or exploration; offering answers and insights; putting work on the board; working with partners or pair-sharing, as appropriate to the assignment; tutoring other students; and supporting other students and a good classroom environment. Students who participate in class are more alert and therefore get more out of classroom instruction, experience better retention of information, and complete homework sessions in a shorter time.

<u>Materials</u>

All students must have the following in class on a daily basis:

- Three-ring loose-leaf binder for notes and homework
- Blue or black ballpoint pen
- Two no. 2 pencils
- One colored pen or pencil

- One straightedge
- Covered textbook
- Graphing calculator (TI-83 Plus or TI-84 preferred if purchasing new)

Any student with financial need or for whom buying any of these supplies or paying for the AP Exam is a hardship may make arrangements for funding through the school.

Binders

Each day's notes must be kept in pen, with a topic and date. Homework that supports the notes is to be done in pencil, with date and corresponding textbook page number. These exercises must be corrected from the answers in the back of the book, as well as during pair-sharing sessions in class. All returned quizzes, tests, labs, and special projects are to be corrected and integrated with the classroom notes.

Homework

It is expected that every student will spend *at least* one-half hour each night on written and study homework, with perhaps more time on weekends or as labs/projects come due. Once a week, students should review their notes for the entire course to keep all skills and concepts fresh. If this is done consistently, an hour of study on the night before a test should be sufficient. Preparation time increases in the weeks preceding the AP Exam.

Grading

Grades are computed on a cumulative-point basis (see the Student Evaluation section of my syllabus for a complete explanation). Graded items include quizzes, tests, labs, projects, class participation, notebook completeness and organization, and homework.

Tutorials

Tutoring is available to every student through a variety of means. I assist students by phone in the evening or personally in the morning before homeroom period, during study halls when our schedules mesh, or after school. E-mail questions are welcome from those who do not expect an immediate answer; often this is a good way for students with a long-term absence to clarify their independent study efforts.

Course Objectives

By the end of this AP Statistics course, students should be able to do the following:

- Appreciate the role of statistics in understanding our world
- Examine data (univariate and bivariate) both graphically and numerically to determine patterns, make comparisons, and draw inferences
- Understand density curves in general and the normal distribution in particular
- Use the standard normal distribution for analysis or comparison
- Examine methods of producing data and understand the elements of good experimental design
- Understand the language and laws of probability
- Explore sampling and probability distributions
- Use simulation to replicate experimental conditions
- Conduct significance tests using *z*-, *p*-, *t*-, and chi-square and regression statistics

- Construct confidence intervals with *z*-, *p*-, *t*-, and regression statistics
- Use calculator and computer technology and software to enhance understanding of statistics
- Apply statistical methods to a research question

Course Planner

The following abbreviations and short titles are used to indicate source material: *AP Test Prep* = *Preparing for the Statistics AP Exam with "Stats: Modeling the World, Second Edition"* (Carroll et al.); COMAP video = *For All Practical Purposes; GRB* = *Golden Resource Binder* (instructor's supplement to the textbook); *Precalculus* = Demana et al., *Precalculus*; RVSL = Rice Virtual Lab in Statistics Web site; Sevin = "Discovering Statistics" lab manual; *Statistics* video = *The High-Stakes World of Statistics* (Witzel et al.). See the Teacher Resources section later in this syllabus for full citations.

Assessments appear in brackets in the "Other" column. All tests are chapter tests.

Topic	Time Frame	Text	Assignments (odd-numbered problems required)	Other
SEMESTER 1				
Introduction to statistics	1 day	pp. vii–xvii	Preview text; install *Minitab*	COMAP video, prog. 6; *GRB*, special problem 0
Exploring Data (chapter 1)				
Variables	1 day	pp. 1–7	Exer. 1.1–1.4	
Examining distributions graphically	3–5 days	Section 1.1	Exer. 1.5–1.30	RVSL: Histograms, Bin Width, and Cross Validation (Web simulation); histogram lab (Sevin) [QUIZ 1.1]
Examining distributions numerically	2–4 days	Section 1.2	Exer. 1.31–1.50	RVSL: Mean and Median (Web simulation); numerical summary lab (Sevin) [QUIZ 1.2]
Review	2 days	Chapter summary	Exer. 1.51–1.73	*Statistics* video, pt. 1 [TEST]
Normal Distributions (chapter 2)				
Density curves and normal distributions	2–4 days	Section 2.1	Exer. 2.1–2.18	*Minitab* lab (*GRB*): special problem 2A; assessing normality lab (Sevin) [QUIZ 2.1]
Standard normal distribution	2–3 days	Section 2.2	Exer. 2.19–2.37	[QUIZ 2.2]
Review	2 days	Chapter summary	Exer. 2.38–2.54	[TEST]

Topic	Time Frame	Text	Assignments (odd-numbered problems required)	Other
Examining Relationships (chapters 3 and 4)				
Variables	1 day	pp. 118-23	Exer. 3.1–3.5	COMAP video, prog. 8
Scatterplots	1–2 days	Section 3.1	Exer. 3.6–3.23	[QUIZ 3.1]
Correlation	1–2 days	Section 3.2	Exer. 3.24–3.37	University of Illinois, Correlation Game (Web site); RVSL: Correlation (Web simulation) [QUIZ 3.2]
Least-squares regression	3–4 days	Section 3.3	Exer. 3.38–3.61	RVSL: Regression by Eye (Web simulation); least-squares regression line lab (*GRB*): special problem 3A [QUIZ 3.3]
Review	2 days	Chapter 3 summary	Exer. 3.62–3.77	[TEST]
Transforming data	2–4 days	Section 4.1	Exer. 4.1–4.26	RVSL: Transformations (Web simulation); nonlinear data lab (*GRB*): special problem 4C [QUIZ 4.1]
Cautions: Lurking Confounding Extrapolation Causation	2–3 days	Section 4.2	Exer. 4.27–4.49	
Categorical data	1–2 days	Section 4.3	Exer. 4.50–4.71	[QUIZ 4.2–4.3]
Review	2 days	Chapter 4 summary	Exer. 4.72–4.83	[TEST]
End Marking Period 1				
Producing Data (chapter 5)				
Studies and experiments	1 day	pp. 266-70		COMAP video, prog. 7
Sampling designs	2–3 days	Section 5.1	Exer. 5.1–5.30	Easton and McColl, Statistics Glossary (Web site) [QUIZ 5.1]
Experimental design	3–4 days	Section 5.2	Exer. 5.31–5.58	Experimental design lab (see the Student Activities section of my syllabus) [QUIZ 5.2]
Simulation	3–4 days	Section 5.3	Exer. 5.59–5.72	Simulation lab (*GRB*): special problem 5A [QUIZ 5.3]

Topic	Time Frame	Text	Assignments (odd-numbered problems required)	Other
Review	2 days	Chapter summary	Exer. 5.74–5.88	[TEST]
Probability (chapter 6)				
Randomness	1–2 days	pp. 326-30		COMAP video, prog. 9; *Precalculus*, chap. 9; Annis et al., What Are the Odds? (Web site); Poker Project (see my Student Activities section)
Probability concepts	1–2 days	Section 6.1	Exer. 6.1–6.10	*Precalculus*, sec. 9.1
Counting methods: multiplication principle, permutations, combinations	2–3 days			*Precalculus*, sec. 9.2
Probability models	3–4 days	Section 6.2	Exer. 6.11–6.44	*Statistics* video, pt. 2; *Precalculus*, sec. 9.2 [QUIZ 6.1–6.2]
General probability rules	2–3 days	Section 6.3 (pp. 359-65)	Exer. 6.45–6.53	*Precalculus*, sec. 9.3
Conditional probability	2–3 days	Section 6.3 (pp. 366-82)	Exer. 6.54–6.77	*Precalculus*, sec. 9.4 [QUIZ 6.3]
Review	2 days	Chapter summary	Exer. 6.78–6.87	[TEST]
Random Variables (chapter 7)				
Discrete vs. continuous	1 day	Section 7.1	Exer. 7.1–7.20	[QUIZ 7.1]
Means and variances	2–3 days	Section 7.2	Exer. 7.21–7.53	[QUIZ 7.2]
Review	1 day	Chapter summary	Exer. 7.54–7.68	[TAKE-HOME TEST]
Distributions of Discrete Random Variables (chapter 8)				
Binomial	1–2 days	Section 8.1	Exer. 8.1–8.36	*Precalculus*, sec. 9.4; RVSL: Normal Approximation to the Binomial Distribution (Web simulation)
Geometric	1–2 days	Section 8.2	Exer. 8.37–8.54	[QUIZ 8.1–8.2]
Review	1 day	Chapter summary	Exer. 8.55–8.64	[TAKE-HOME TEST]
End Marking Period 2				
Review for examination	2 days	Chapters 1–8		[MIDTERM EXAMINATION]

Topic	Time Frame	Text	Assignments (odd-numbered problems required)	Other
SEMESTER 2				
Sampling Distributions (chapter 9)				
Statistical inference	1 day	pp. 484-88		COMAP video, prog. 10
Parameters and statistics	1–2 days	Section 9.1	Exer. 9.1–9.18	[QUIZ 9.1]
Sample proportions	2–3 days	Section 9.2	Exer. 9.19–9.30	Sample proportions lab (Sevin) [QUIZ 9.2]
Sample means	1 day	Section 9.3 (pp. 514-19)	Exer. 9.31–9.35	
Central limit theorem	1–2 days	Section 9.3 (pp. 520-26)	Exer. 9.36–9.42	RVSL: Sampling Distributions (Web simulation); *Minitab* lab (*GRB*): special problem 9A [QUIZ 9.3]
Review	2 days	Chapter summary	Exer. 9.43–9.53	[TEST]
Inference (chapter 10)				
Confidence intervals	2–3 days	Section 10.1	Exer. 10.1–10.26	Confidence interval lab (Sevin) [QUIZ 10.1]
Significance tests	3–4 days	Sections 10.2–10.3	Exer. 10.27–10.65	[QUIZ 10.2–10.3]
Error and power	2–3 days	Section 10.4	Exer. 10.66–10.77	Intuitor.com, Type I and Type II Errors (Web simulation); Anderson-Cook, Hypothesis Testing (Web simulation) [QUIZ 10.4]
Review	1–2 days	Chapter summary	Exer. 10.78–10.89	[TEST]
Inference for Distributions (chapter 11)				
One-sample *t* procedures	2–3 days	Section 11.1	Exer. 11.1–11.21, 11.23c, 11.24–11.34, 11.36	[QUIZ 11.1]
Two-sample *t* procedures	2–3 days	Section 11.2	Exer. 11.37–11.61	[QUIZ 11.2]
Review	1 day	Chapter summary	Exer. 11.62–11.73	[TEST]

Topic	Time Frame	Text	Assignments (odd-numbered problems required)	Other
Inference for Proportions (chapter 12)				
One-sample	1–2 days	Section 12.1	Exer. 12.1–12.21	[TAKE-HOME QUIZ 12.1]
Two-sample	2–3 days	Section 12.2	Exer. 12.22–12.34	Simulations and inference lab (*GRB*): special problem 12A [TAKE-HOME QUIZ 12.2]
Review	1–2 days	Chapter summary	Exer. 12.35–12.45	[TEST]
Inference for Tables (chapter 13)				
Chi-square test for goodness of fit	1–2 days	Section 13.1	Exer. 13.1–13.13	[QUIZ 13.1]
Chi-square test for homogeneity	1–2 days	Section 13.2 (pp. 750-57)	Exer. 13.14–13.18	
Chi-square test for independence	1–2 days	Section 13.2 (pp. 757-69)	Exer. 13.19–13.30	[QUIZ 13.2]
Review	1 day	Chapter summary	Exer. 13.31–13.40	[TEST]
End Marking Period 3				
Inference for Regression (chapter 14)				
Inference for slope	1–2 days	Section 14.1	Exer. 14.1–14.11	*AP Test Prep*, intro and topics 1–2 [QUIZ 14.1]
Predictions	1–2 days	Section 14.2	Exer. 14.12–14.17	*AP Test Prep*, topic 7 [TAKE-HOME QUIZ 14.2]
Review	1 day	Chapter summary	Exer. 14.18–14.27	[TEST]
Intensive cumulative review for AP Exam	5–10 days			*AP Test Prep*, topics 3–6; released AP Exam questions (AP Central)
Intensive cumulative review for AP Exam	5 days			*AP Test Prep*, practice exams; released AP Exam questions (AP Central)
AP EXAM				
Post–AP Exam project	10–15 days			Independent research
End Marking Period 4				

Teaching Strategies

I introduce the major conceptual components of the course by using individual programs from the video series *For All Practical Purposes*. These informal and conversational episodes are an effective way to familiarize students with the basic vocabulary and common applications for the skills they are about to learn.

I use *PowerPoint* for most of my classroom presentations, so I can thereby incorporate Web sites of interest, charts, and graphs into the lecture. Students take their own notes, and sample problems and discussion are woven into the presentation; problem sets are done outside of class. Students then discuss these problems with their "pair-share partners" in order to identify and work out difficulties. Any problems that remain unsolved are presented to the class for resolution by the rest of the group (and me).

The "pair-share" technique works well. A pair forms a cooperative learning unit and can join another pair to form a lab group. My classroom presentations are often Socratic: I ask questions to stimulate thinking. Students are frequently reluctant to take the risk of answering such questions, but they become bolder after a discussion with a partner. The partners take academic responsibility for one another and push each other toward better performance in homework, labs, quizzes, and tests. The partner is the first source of information for students who miss class. In the first marking period, students are often paired with a partner from another grade to build familiarity. In the second marking period, I pair students based on their first-marking-period performance (strong with weak) and by observed personalities. In the third marking period, I pair them based on their midterm examination grades. Because that examination mimics the AP Exam and uses questions from AP Released Exams as its base, students who have demonstrated facility with these kinds of questions can help those who are less agile in an exam situation. In the fourth marking period, students may choose their own seats in the classroom, and that seating determines the partners or groups.

Most chapters are explored on the front end or reinforced on the back end with a lab, often in the form of one of the "special problems" in the *Golden Resource Binder* that accompanies our textbook. I refer to any class-long group activity or individual investigation as a "lab," and students follow the guidelines in the *Binder*'s "special problem 0" to report their results; or, in the case of the labs developed by Anne Sevin, they complete these together with their partner(s) and report them on the form provided. Many of the special problems require the use of *Minitab* or similar spreadsheet and graphing software. Students are provided with a copy of *Minitab* at the beginning of the year, and one of the first labs (special problem 2A) is an exploration of its capabilities. The directions are included with the lab. Students who have other software at home are permitted to substitute it (after checking with me.)

There are three computer stations, plus the teacher's laptop, available in my classroom. When an applet is useful (e.g., Correlation Game Web site), students form teams and utilize these four stations to inform or compete. Simulation labs are done with the calculator or computer. *Minitab* labs are done with the software loaded on the classroom, math lab, or home computers of the students. (The classroom computer or math lab computers may be used only by students who do not have a computer at home.) *Minitab* labs are most frequently done independently (without partners).

Students always read the requirements for a lab or project and ask questions in the classroom before beginning the work. I allot a one- to two-week time frame in which I expect them to complete the assignment independently, but we determine the actual due date collaboratively. (I ask, "Having read the requirements, what do you think is a reasonable amount of time to complete this lab?") Some labs are completed during class time with partners. These are often ones that require experimentation rather than simulation—dice rolling, penny spinning, and the like. The experimental design activity (described in the Student Activities section at the end of my syllabus) and many of Anne Sevin's labs are best done in the classroom. They are handwritten reports.

For assessments, I use the test and quiz resources in the textbook because I find that they closely model the AP Exam question types. I give take-home quizzes or tests for short chapters, for chapters at the close of the semester, or just before the AP Exam purely as a timesaver. With juniors in the course, teaching time in the third marking period is seriously impacted by our mandatory state assessments, which eat up nearly a week of instructional time. I sometimes ask students to do the assessment at home without the aid of text or notes, but on other occasions I use a take-home quiz or test as a teaching aid.

To prepare students for the AP Exam, I facilitate the purchase of a review book. In the past I have used the AMSCO book by Jim Bohan, but most recently I have been using the Pearson/Prentice Hall book that is ancillary to David Bock et al.'s *Stats: Modeling the World*. (Disclaimer: I am one of the authors of this test prep book, a fact I also disclose to my students.) All students purchase their own copies; I place a group order, accept shipment, and usually pay shipping and handling. They use the book to prepare independently for midterms. In the two to three weeks prior to the AP Exam, I specify chapters from the textbook and test prep book for review and then give in-class quizzes on the review topics. These quizzes consist of short-answer questions from the Released Exams that address the particular concept or skill, and students are placed under time restrictions similar to those of the AP Exam. I grade the quizzes based on my experience with the AP Exam Scoring Guidelines and return the papers for discussion the next day. We often review the scoring procedures as a group and look at sample answers. Weekend assignments are the practice exams from the test prep book.

After the AP Exam, students are generally free of homework. All work is completed during class. We explore opportunities for research and analysis that will assist the school community. Some project themes are proposed by the administration, and other research ideas come from students. Prior years' themes have addressed the following questions:

- Does the day or the grade level or a combination of these factors influence absence rates at Kennett High School?
- How does the evacuation alarm compare with the ambient noise levels at Kennett High School?
- Are students satisfied with the cafeteria offerings in the Kennett Consolidated School District?
- Does extracurricular activity impact grade point average?

Student Evaluation

Students are graded on a point system, with each quiz contributing 10–25 points; each test, 50–90 points; each lab, approximately 50 points; homework for the marking period, approximately 50 points; notebook binder, approximately 50 points; and classroom participation, approximately 50 points. Roughly, tests account for 35 percent of the grade; quizzes, 20 percent; labs, 30 percent; homework, 5 percent; binder, 5 percent; and class participation, 5 percent. It varies according to the number of activities I can accomplish with any given group.

Tests (taken from the *Golden Resource Binder*) are point balanced between the multiple-choice and the free-response questions, to anticipate AP Exam scoring. All AP courses at Kennett High School are weighted at 5.0 on a 4.0 scale. Each of the four marking periods is graded separately, and the cumulative points create a percentage that corresponds to a letter grade. That letter grade contributes a certain number of points to the student's GPA. The GPA points are accumulated over the four marking periods, then doubled in value, added to the midterm letter grade GPA value, and averaged to arrive at the final year-end letter grade. The school's grading scale is as follows:

Marking Period and Examination Letter Grades		Regular Courses GPA	Honor Courses GPA	AP Courses GPA
A+	97–100	4.33	4.83	5.33
A	93–96	4.00	4.50	5.00
A–	90–92	3.67	4.17	4.67
B+	87–89	3.33	3.83	4.33
B	83–86	3.00	3.50	4.00
B–	80–82	2.67	3.17	3.67
C+	77–79	2.33	2.83	3.33
C	73–76	2.00	2.50	3.00
C–	70–72	1.67	2.17	2.67
D+	67–69	1.33	1.83	2.33
D	60–66	1.00	1.50	2.00
X	50–59	0.00	0.00	0.00
Y	Below 50	−1.00	−1.00	−1.00

Teacher Resources

Primary Text

Yates, Daniel S., David S. Moore, and Daren S. Starnes. *The Practice of Statistics: TI-83/89 Graphing Calculator Enhanced*. 2nd ed. New York: W. H. Freeman, 2003.

Related Print Resources

Barat, Christopher. *The Practice of Statistics Instructor's Solution Manual*. 2nd ed. New York: W. H. Freeman, 2003.

Fligner, Michael A., and William I. Notz. *The Practice of Statistics Printed Test Bank*. 2nd ed. New York: W. H. Freeman, 2003.

Yates, Daniel S., and Daren S. Starnes. *The Practice of Statistics Golden Resource Binder*. 2nd ed. New York: W. H. Freeman, 2003.

Supplementary Materials

Books

Bohan, James. *AP Statistics: Preparing for the Advanced Placement Examination*. New York: AMSCO, 2000.

Carroll, Anne M., Ruth E. Carver, Susan A. Peters, and Janice D. Ricks. *Preparing for the Statistics AP Exam with "Stats: Modeling the World," 2nd ed.* AP Test Prep series. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2007.

College Board. 1997 *AP Statistics Released Exam*. New York: College Board, 1997.

College Board. 2002 *AP Statistics Released Exam*. New York: College Board, 2002. (Note: The 2007 Released Exam has become available since this syllabus was submitted.)

Demana, Franklin, Bert K. Waits, Gregory D. Foley, and Daniel Kennedy. *Precalculus: Graphical, Numerical, Algebraic*. 6th ed. Boston: Pearson/Addison-Wesley, 2004.

Lovell, Robert. *Probability Activities: For Problem Solving and Skills Reinforcement*. Emeryville, Calif.: Key Curriculum Press, 1993.

Scheaffer, Richard L., Mrudulla Gnanadesikan, Ann Watkins, and Jeffrey A. Witmer. *Activity-Based Statistics: Instructor Resources*. New York: Springer, 1996.

Sevin, Anne D. "Discovering Statistics: An Interactive Approach." Workshop presentation, 1995. From an unpublished laboratory manual, "Laboratory Manual for Introductory Statistics," Framingham State College, Framingham, Massachusetts, spring 1993.

Software and Other Technology

Minitab. Student Version. Release 12. 1998.
www.minitab.com.

Texas Instruments. TI-84 Plus Graphing Calculator and ViewScreen.
http://education.ti.com/educationportal/sites/US/homePage/index.html.

Video

For All Practical Purposes: An Introduction to Contemporary Mathematics, episodes 6–10. 1987. Produced by the Consortium for Mathematics and Its Applications (COMAP). An Annenberg/CPB Project. VHS/DVD. Distributed by Intellimation, Santa Barbara, Calif. 30 minutes per episode.

The High-Stakes World of Statistics (Parts 1, 2, and 3). 1998. Directed by Jonathan Reich. Performed by the Standard Deviants. Academic consultants: Ronald Witzel and Barry Skolnik. VHS. Distributed by Cerebellum Corporation, Falls Church, Va. Three videocassettes, 261 minutes.

Web Sites

Anderson-Cook, C. M., and S. Dorai-Raj. Hypothesis Testing.
www.amstat.org/publications/jse/v11n3/java/Hypothesis.
Web site to accompany "Making the Concepts of Power and Sample Size Relevant and Accessible to Students in Introductory Statistics Courses Using Applets." *Journal of Statistics Education* 11, no. 3 (2003).

Annis, Rebekah et al. "What Are the Odds? The Ins and Outs of Probability."
http://teacherlink.org/content/math/interactive/probability/home.html.

Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).
www.causeweb.org/resources.

Easton, Valerie J., and John H. McColl. Statistics Glossary.
www.cas.lancs.ac.uk/glossary_v1.1/samp.html.

Intuitor.com. Type I and Type II Errors—Making Mistakes in the Justice System.
www.intuitor.com/statistics/T1T2Errors.html.

Rice Virtual Lab in Statistics.
http://onlinestatbook.com/rvls.html.

University of Illinois at Urbana–Champaign. Department of Statistics. The Correlation Game.
www.stat.uiuc.edu/courses/stat100/java/GCApplet/GCAppletFrame.html.

W. H. Freeman Co. *The Practice of Statistics.* 2nd ed. Companion Web site.
http://bcs.whfreeman.com/yates2e.

Student Activities

The Poker Project

(Topic: Probability)

Goal

Students use a basic understanding of probability, the fundamental counting principle (multiplication principle), and the combinations rule to count the number of possible hands and their probabilities for winning at five-card poker.

The Problem

On an initial deal of five cards to any one player, list the 10 possible hands in poker, and count the number of ways to acquire each of those hands. Students may use books or the Internet to assist them but are encouraged to do their computations independently and check that they have accounted for the entire sample space before using other resources. If sources are used (and students are encouraged to check), they must be cited in proper form as part of the paper.

The Product

Each student must hand in a typed paper, which may be as creative in design as desired. The paper must include not only the probability of each hand but the explanation, with proper notation, of how the probability was derived. (This part is unique to each student: although students may get answers and techniques from another source, the explanations must be their own.)

Evaluation

This project is graded on the correctness of each hand and the quality of the explanation (4 points for each hand), as well as the presentation and proper citation (10 points).

Experimental Design Activity

(Topic: Experimental Design)

Goal

The students demonstrate an understanding of design in both paragraph and diagram formats. In intent, this activity is similar to question 2 about waterproofing boots that appeared on the 2002 AP Exam.

The Problem

An antidepression drug on the market has an effective period of 8 to 10 hours for each dosage. A number of patients have complained that they have experienced dryness as a side effect and are therefore increasing their water consumption. The pharmaceutical company has decided to investigate this side effect. You are asked to design an experiment to determine the significance of this claim. You have been given eight days to complete this experiment, and the subjects are 20 single-housed, healthy, young adult male Sprague Dawley rats. (Previous animal experiments have shown that dryness is an indication that can be determined by using rats as subjects, and we have determined the proper dosing range for rats.)

Describe and diagram your design. Be prepared to discuss.

The Product

Each group submits a handwritten report at the end of the class period.

Evaluation

Students generally work on this problem in groups of two to four. One design is submitted and graded on a 20-point scale. A class discussion of the various designs follows.

Post–AP Exam Project

(Topic: A combination of AP Statistics topics—student/teacher/school-driven)

Goal

Students use the statistical methods they have studied to analyze and report on a topic of interest to the Kennett High School community. This topic is chosen collaboratively.

The Product

Each team of students works on a different aspect of the analysis (e.g., collecting data, graphical displays, inference). The teams then unify their work into a single report. A sample report follows. The objective of this particular project was to determine whether the ambient noise at Kennett High School exceeded safe levels. Students were provided with devices to record the ambient noise (courtesy of a local codes official).

> We took 11 separate ambient noise level readings from different areas at the high school. The mean of these 11 noise levels was 93.45 decibels. Using statistical methods we also constructed three confidence intervals in which we are x percent confident that the true mean actually lies, x being either 90 percent, 95 percent, or 99 percent, depending on the confidence level. These confidence intervals are centered around the sample mean.
>
> The 90 percent confidence interval is 87.53 decibels to 99.37 decibels. The 95 percent confidence interval is 86.17 decibels to 100.73 decibels. The 99 percent confidence interval is 83.10 decibels to 103.80 decibels. Taking the 99 percent confidence interval, for example, we are 99 percent confident that the true mean of the ambient sound level in those certain areas lies between 83.10 decibels and 103.80 decibels.

Evaluation

The project is graded as class participation for the individuals as they work in their teams. This constitutes most of a student's class participation grade for the fourth marking period.

Sample Syllabus 5

Dora Daniluk
Mayde Creek High School
Houston, Texas

School Profile

Location and Environment: Mayde Creek High School, one of six high schools in the Katy Independent School District, is located 25 miles west of downtown Houston. The district, encompassing 181 square miles in eastern Texas, has seen student enrollment steadily grow to more than 50,000 in the 2006-07 school year, with just under 3,000 of these pupils at Mayde Creek High.

Our school is academically grounded, technologically advanced, student-centered, community-supported, and respectful of individuals. The curriculum is broad-based and includes a strong AP program, dual credit for courses with the local community college, a special program for gifted and talented students, and international business and career/technology offerings.

Grades: 9–12

Type: Public, four-year secondary school

Total Enrollment: Approximately 2,600

Ethnic Diversity: Hispanics/Latinos constitute 38 percent of the population; African Americans, 14 percent; Asian Americans, 6 percent; and others, 1 percent.

College Record: Of the class of 2006, 63 percent went on to attend a four-year college, 29 percent enrolled in a two-year college, 3 percent received further vocational training, and 4 percent entered the military.

Personal Philosophy

Students who enroll in my classes vary greatly in their mathematical backgrounds and abilities. For many, this class provides their first or only AP experience, whereas others have a schedule filled with AP courses. I do believe that this is one course where all students can feel a measure of accomplishment. Statistics *is* the real world around us, and relating activities and learning to what students see and know can stimulate interest and success. I believe that activity-based lessons are essential to present concepts, and as a result, each chapter in our textbook involves at least one activity that will help students discover, learn, and/or recall the needed material. The classroom involves cooperative learning—a chance to share ideas, discuss problems, and explore possible answers. This team atmosphere is a major reason that 90 percent of our students consistently earn grades of 3 or better on the AP Exam.

Class Profile

Mayde Creek High School usually has two sections of AP Statistics, with approximately 25 to 30 students in each; I teach both classes. We are on a traditional schedule, and the class meets daily for 45 minutes. The course prerequisite is Algebra 2, and as a result the students vary in ability from those who have only Algebra 2 in their math background to those who are currently taking AP Calculus. Our district has an open-door policy for AP courses, and all students are encouraged to enroll in these classes. All AP courses provide an extra bonus point toward calculating a student's grade point average on our 4-point scale. Although our school does not require AP students to take AP Exams, students in this course are strongly encouraged to do so, and on average, more than 80 percent take the exam.

Course Overview

The aim of this AP course is to provide students with a learning experience equivalent to that obtained in most college introductory statistics courses, which have become a requirement for many college majors. Students are expected to complete college-level assignments and be sufficiently motivated and self-disciplined to perform at a postsecondary level. The course involves four major topics: exploring data, planning a study, anticipating patterns, and statistical inference. The skills and concepts listed in the Topic Outline of the *AP Statistics Course Description* are all covered. In addition to mastering skills and understanding concepts, I hope each student will develop an awareness of the importance of this subject in the real world, improve communication skills to convey decisions and ideas, and apply this knowledge in the future.

TI-83 or -84 calculators are essential for success, and the mathematics department permits rental of calculators for students who are unable to make such a purchase. There is no formal lab component in this course. The computer lab is used only for Internet activities found at the textbook publisher's Web site or at various other sites listed in the Teacher Resources section of this syllabus. In past years this has involved one or two days in the lab, as well as having students research specific sites from home.

The primary statistics text for the district is *The Practice of Statistics: TI-83 Graphing Calculator Enhanced* by Yates, Moore, and McCabe.

Course Planner

Our academic year consists of two semesters, with school beginning in late August and running through the end of May. In the timetable below, the number of days in the "Time Frame" column indicate the actual number of classroom instruction days—that is, 15 days equals three weeks, exclusive of school breaks, holidays, and test days. There is a test at the end of each instructional unit and a semester exam at the end of each semester.

Textbook problem numbers are not always listed in numerical order because the problems sometimes piggyback one another, and the sequence listed allows students to continue the same line of thought.

The following abbreviations are used to indicate book titles: *ABS* = *Activity-Based Statistics* (Scheaffer et al.); *PS* (course textbook) = *The Practice of Statistics* (Yates et al.); *SIA* = *Statistics in Action* (Watkins et al.); *SMW* = *Stats: Modeling the World* (Bock et al.); *WS* = *Workshop Statistics* (Rossman and von Oehsen). See my Teacher Resources section for full citations.

SEMESTER 1

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~15 days	**Exploring Univariate Data** *Topics* • Displaying distributions with graphs • Describing distributions with numbers *Assignments* • *PS*, chapter 1, problems 5, 7, 8, 14, 16, 18, 35, 41, 43, 54, 55 • *SIA*, p. 93	*Activities* • Distribution activity • "Features of a Distribution," *WS*, pp. 29–34 • Matching graphs to variables and matching statistics to graphs, *ABS*, pp. 31–40 *Strategies* • A student survey from the first day of class that collects nonsensitive information (favorite fast-food restaurant, number of DVDs owned, etc.) can be used for graphical displays and discussion of types of data, as well as future topics. • TI graphing features are used extensively. (Beware, however, of teaching too many calculator functions, such as renaming lists; weaker students may be overwhelmed by this additional information.) • Assign several past AP Exam free-response questions to make students more aware of expectations and methods of scoring these questions—e.g., 2001, no. 1. • Introduce transformation of data and the resulting effects on measures of center and spread—later referenced in chapter 7.
~7 days	**Counting Techniques and Probability** *Topics* • Randomness • Probability models *Assignments* • Worksheets to review basic counting techniques, including combinations and permutations • Probability review worksheets • *PS*, chapter 6, problems 8, 9, 12, 13, 19, 21, 22, 23, 31–33, 39, 40	*Activities* • Students select lottery numbers on the day we begin this chapter, and drawings are done on a daily basis. (The Texas Lottery consists of selecting six numbers from 1 to 54.) A calculator is used to randomly select six numbers at the beginning of class, and prizes are given for matching four, five, or six numbers. And yes, very few prizes are given. *Strategies* • Provide as much practice as possible in this section. • A review of basic probability at this point has proved to be beneficial before addressing probabilities found using different density curves.

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~9 days	**The Normal Distribution** *Topics* • Density curves • Normal distributions • Standard normal calculations • Assessing normality *Assignments* • *PS*, chapter 2, problems 2, 3, 4, 7, 9, 13, 17, 26, 27, 30, 31, 33, 39, 40, 43	*Activities* • Group problems from *SMW*, pp. 93–95 *Strategies* • A calculator is used to find the probability on the standard normal curve. I do not teach too many shortcuts at this time. • Draw connections with chapter 1, such as graphing data and finding the quartiles for the normal curve. • Past AP Exam free-response question practice: 2003, no. 3.
~10 days	**Examining Relationships** *Topics* • Scatterplots • Correlation • Least-squares regression *Assignments* • *PS*, chapter 3, problems 1, 2, 5, 7, 11, 42, 43, 10, 26, 30, 36, 38, 50	*Activities* • Activities to demonstrate the meaning of LSRL and the coefficient of determination: Using the data from example 3.12, we calculate the sum of the squares of the residuals for the line $y = 4 + .5x$. Students then try to find a “better line” with a smaller sum of squares. A calculator is then used to show the LSRL, and the minimal sum is calculated. • *PS* computer lab activity from the textbook Web site • Web sites related to these concepts (GC Applet and Regression Applet in the Teacher Resources section of this syllabus) • Matching descriptions to scatterplots activity, *ABS*, pp. 83–85 *Strategies* • Go slowly and show as many examples as possible. • Emphasize all steps needed to analyze the data. • “Recipes” for slope and coefficient of determination are helpful for students to learn, but be sure these concepts are understood.

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~10 days	**More on Regression Analysis and Two-Variable Data** *Topics* • Modeling nonlinear relationships—log and power transformations, piecewise functions • Interpreting correlation and regression • Relations in categorical data *Assignments* • Review worksheet on logs and exponentials • *PS*, chapter 4, problems 51, 52, 54, 7, 9, 10, 12, 61, 19–24, 38, 39, 65, 40, 41, 43, 64	*Activities* • Have students collect data in a variety of ways and find the best model to fit their data—e.g., the Cheerios® exploration available on Jared Derksen's Web site (www.mrderksen.com/Downloads/cheerios.pdf). *Strategies* • Most of my students need a one-day review of logs and exponentials. • Group activities work well in this unit. • Now is a good time to practice past AP Exam free-response questions (such as no. 1 from 2005).
~15 days	**Samples and Experiments** *Topic* • Designing samples • Designing experiments • Simulating experiments *Assignments* • *PS*, chapter 5, problems 1, 4, 5, 7, 9–12, 14–25, 27, 31, 33, 29, 40, 45, 47 • Group experiment based on the Helicopter Project (see the Student Activities section of this syllabus)	*Activities* • "Random Rectangles," *ABS*, pp. 154-55. Systematic, cluster, and stratified sampling is also demonstrated. *Strategies* • Students find examples of recent experiments or studies and then analyze according to principles learned in this chapter. • Vocabulary for this chapter needs to be stressed. • Past AP Exam free-response question practice: 2002, no. 2; 2004 (Form B), no. 2.
~9 days	**Probability Revisited** *Topic* • Probability tables and trees (section 6.3) • Law of large numbers • Simulating probability (section 5.3) *Assignments* • *PS*, chapter 6, problems 50, 53, 54, 45, 47, 49, 51, 60 • Worksheets using problems from a variety of texts to supplement table and tree problems	*Activities* • Play the Game of Greed (URL is in my Teacher Resources section) to introduce simulations. Rules of the game: Students stand. Single die is rolled twice and total is counted. Students may sit and retain this total or stand for additional rolls. Any roll of 6 erases the accumulated total, and winner(s) are those students who most recently sat down. On average, how many points would you expect to earn? • Textbook Web site simulation of the law of large numbers.

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~6 days	**Random Variables** *Topics* • Discrete and continuous random variables • Means and variances of random variables *Assignments* • *PS*, chapter 7, problems 3, 7, 8, 9, 11, 10, 17, 27, 18, 19, 25, 26, 29, 24, 30, 31, 32	*Activities* • "Random Behavior," *ABS*, pp. 93–95 • Spinner activity to demonstrate transformations and combinations of random variables • Dice activity to demonstrate that $2x$ is different from $x + x$ *Strategies* • Keep in mind that rules about means and variances for linear combinations of random variables are not on the formula chart for the AP Exam. These topics need to be included with problems in future chapters.

SEMESTER 2

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~6 days	**The Binomial and Geometric Distributions** *Topics* • Binomial distributions • Normal approximation to the binomial • Geometric distributions *Assignments* • *PS*, chapter 8, problems 19–23, 24, 29, 41 • Additional worksheets	*Activities* • Binomial Rabbits demo from NetLogo (see my Teacher Resources section) • Normal approximation to the binomial demo (see the Teacher Resources section) • M&M's to demonstrate binomial and geometric distributions • Student pairs graph binomial distributions on classroom board—from $p = .1$ to $p = .9$. Compare the graphs; calculate the mean and standard deviation for each using formulas from chapter 7; then compare these results to formulas for binomial distributions. *Strategies* • Students need to see a variety of examples to emphasize the difference between binomial and geometric distributions.

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~10 days	**Sampling Distributions** *Topics* • Sampling distributions • Sample means • Introduction to confidence intervals *Assignments* • *PS*, sections 9.1, 9.3, 10.1; chapter 9, problems 1, 4, 10, 33, 37, 39, 43, 45; chapter 10, problems 1–3, 5, 14, 6, 11, 16, 24	*Activities* • *PS* activity 9A (alternate) to demonstrate the central limit theorem (CLT). I have a dozen sets of these numbers, as well as four sets of a uniform distribution. Use one-inch graph paper to record data. I select sample sizes of 3, 5, and 10 from the normal distribution and sample size of 10 from the uniform. Displaying these graphs for the remainder of the year proves beneficial to remind students that sample size (not population size) is important in determining the variation of the sampling distribution. *Strategies* • Using the sets of numbers for the normal distribution (described above), students graph a confidence interval and note if it captures the true mean of the population. • There are some really nice software models demonstrating the central limit theorem (see Sampling Distribution and CLT Model in my Teacher Resources section). • Understanding of the CLT is very important; time here is well spent.
~9 days	**Introduction to Significance Tests and Inferences** *Topics* • z tests and intervals • Type I and II errors • Power *Assignments* • *PS*, various problems are selected, but format involves parameter of interest, conditions, hypotheses, graph, test statistic, P-value, and conclusion • *PS*, chapter 10, problems 61, 62, 63, 64 • *SMW*, problems from pp. 418-19	*Strategies* • Students need to memorize much of the vocabulary in this chapter. • Students begin a portfolio of all types of inference tests and intervals. • Although calculating power and probability of Type II errors is not required material, both are valuable in demonstrating the relationships between Type I, Type II, power, sample size, and effect size.

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~9 days	**Inferences for One-Sample Distributions** *Topics* • Sampling proportions • Inference for the mean of a population (sigma unknown) • Inference for a population proportion *Assignments* • *PS*, sections 9.2, 11.1, 12.1; chapter 9, problems 15, 19, 21, 23, 25; chapter 11, problems 1, 5, 6, 9, 11, 12, 13, 14; chapter 12, problems 1–11 (odd) • Worksheet with mixed practice	*Activities* • Activities to gather data and to reinforce experimental design and sampling concepts from chapter 5 *Strategies* • Students need to analyze computer data for this section (and the ones to come). Output from different computer programs should be utilized. • Examples of each type of test and interval are added to the students' portfolios.
~7 days	**Inferences for Two-Sample Distributions** *Topics* • Comparing two means • Comparing two proportions *Assignments* • *PS*, chapter 11, problems 31–33, 37, 39, 43, 44; chapter 12, problems 21–24	*Activities* • Activities to gather data for analysis and reinforcement of experimental design and sampling concepts • Ongoing portfolio project *Strategies* • Past AP Exam free-response questions covering inferences
~8 days	**Chi-Square Procedures** *Topics* • Goodness of fit • Homogeneity of proportions • Independence *Assignments* • *PS*, chapter 13, problems 1, 3, 4, 12, 21, 30 • Worksheets with mixed types of inference studied to this point	*Activities* • Test of homogeneity: For a quiz grade, each student receives a cup of multi-fruit-colored cereal and determines if the colors are equally distributed. After the quiz, they check the bottom of their cups to determine which kind of "Froot Loops®" they have (three different brands of cereal are used in the class). *Strategies* • Test after this unit on chapters 9–13 combined: This exam (the only one in the course that covers multiple units) combines all of the different types of intervals and tests. I feel that tying all of these topics together is important to success in this area.

Time Frame	Unit Title, Topics, and Assignments	Resources, Activities, and Strategies
~7 days	**Inference for Regression** *Topics* • Hypothesis test for slope • Confidence interval for slope • Computer output *Assignments* • Review worksheets on linear regression and transformations to achieve linearity • Computer data printouts • AP Exam questions	*Activities* • Cooperative assignments and review worksheets *Strategies* • Review chapters 3 and 4 for AP Exam. • Students need to be able to analyze data from different types of computer software.
~ 10 days	**Review for AP Exam** *Assignments* • Multiple-choice and free-response questions from AP Central and Released Exams	
~ 10 days	**Post–AP Exam Period** *Topics* • Games of chance • Apply principles of probability in developing a game of chance	*Activities* • Game of Chance project (see my Student Activities section)

Teaching Strategies

I have integrated my specific teaching strategies for each segment of the syllabus into the Course Planner above. Here I describe some of the broader instructional methods that I employ.

I start most class periods with a short warm-up question that reviews recently presented material. These problems are graded as correct or incorrect, and the points earned are recorded for each student. Individual accumulated points become a quiz grade at the end of the grading period—based on five-eighths of the total points possible. As the year progresses, I begin class once a week with 12-minute timed warm-ups, using free-response questions similar to those that appear on the AP Exam.

Group points are earned in cooperative activities. For example, I often distribute challenging multiple-choice questions (at a higher level of difficulty than most of my test questions) to groups of students in order to review for a test. These encourage discussion in the group and give the students good practice. At the end of each six weeks, group points are converted into a quiz grade, based on the average number of points earned by the class groups. Such a quiz is usually a benefit to student averages. New groups are determined randomly (of course) every six weeks.

I am a strong believer in learning by doing, so a great deal of my instruction is based on classroom activities that reinforce the material being taught. Students learn abstract concepts best from practical applications, and they also enjoy engaging in hands-on projects. For instance, because it has a second-story balcony, my school offers the perfect place to stage the Helicopter Project described on the North Carolina

School of Science and Mathematics (NCSSM) Web site. (For a complete description of this and several other such undertakings, see the Student Activities section at the end of this syllabus.) I have found the amount and quality of learning that students derive from group activities to be well worth the additional time required.

Once we begin to study inference, I have the students develop a portfolio that contains examples of each type of hypothesis test and confidence interval (see the Student Activities section). The total points earned are counted as a test grade, but most important, students claim that this collection of their work provides the best study material for the AP Exam. I use released AP Exam questions for many of these problems, but I vary them from year to year, because the portfolios tend to be saved by former students.

Student Evaluation

Students' transcripts show two semester grades, both of equal value. Each semester has three six-week grading periods and a semester exam, each worth 25 percent of the semester grade. District guidelines require that each six-weeks' grade be determined as follows:

Tests: 70 percent

Quizzes: 20 percent

Daily class work and homework: 10 percent

There is a test at the end of each instructional unit. All unit tests are half multiple-choice and half free-response questions. Semester exams are 70 percent multiple-choice and 30 percent free-response. The second-semester exam is a comprehensive final. Quizzes are given periodically—either announced or unannounced—in order to assess students' knowledge of the material on a day-to-day basis.

The school's grading scale is as follows:

90–100	A
80–89	B
75–79	C
70–74	D

Teacher Resources

Primary Textbook

Yates, Daniel S., David S. Moore, and George P. McCabe. *The Practice of Statistics: TI-83 Graphing Calculator Enhanced*. New York: W. H. Freeman, 1999.

Supplementary Books

Bock, David E., Paul F. Velleman, and Richard D. De Veaux. *Stats: Modeling the World*. Boston: Pearson/Addison-Wesley, 2004.

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. 2nd ed. Pacific Grove, Calif.: Brooks/Cole, 2005.

Rossman, Allan J., and J. Barr von Oehsen. *Workshop Statistics: Discovery with Data and the Graphing Calculator*. New York: Springer, 1997.

Scheaffer, Richard L., Mrudulla Gnanadesikan, Ann Watkins, and Jeffrey A. Witmer. *Activity-Based Statistics: Instructor Resources*. New York: Springer, 1996.

Utts, Jessica M., and Robert F. Heckard. *Mind on Statistics*. 2nd ed. Belmont, Calif.: Thomson Brooks/Cole, 2004.

Watkins, Ann E., Richard L. Scheaffer, and George W. Cobb. *Statistics in Action: Understanding a World of Data*. Emeryville, Calif.: Key Curriculum Press, 2004.

Yates, Daniel S., and Daren S. Starnes. *The Practice of Statistics Golden Resource Binder*. 2nd ed. New York: W. H. Freeman, 2003.

Web Sites

Boggs, Rex. The Game of Greed.
www.lhs.logan.k12.ut.us/~jsmart/greed.htm.

NCSSM Statistics Leadership Institute Notes. The Helicopter Experiment: A Factorial Design.
http://courses.ncssm.edu/math/Stat_Inst/PDFS/FacDesgn.pdf.

Rice Virtual Lab in Statistics. Normal Approximation to the Binomial Distribution.
http://onlinestatbook.com/stat_sim/normal_approx/index.html.

Rice Virtual Lab in Statistics. Sampling Distribution.
http://onlinestatbook.com/stat_sim/sampling_dist/index.html.

University of Illinois at Urbana–Champaign, Department of Statistics. GC Applet.
www.Stat.uiuc.edu/~stat100/java/GCApplet/GCAppletFrame.html.

West, R. Webster, University of South Carolina. Regression Applet.
www.stat.sc.edu/~west/javahtml/Regression.html.

W. H. Freeman Co. *The Practice of Statistics*. 2nd ed. Companion Web site.
http://bcs.whfreeman.com/yates2e.
For my purposes, the Web site for the second edition works fine with the first edition of the textbook.

Wilensky, Uri, Center for Connected Learning and Computer-Based Modeling, Northwestern University.
NetLogo Binomial Rabbits Model.
http://ccl.northwestern.edu/netlogo/models/BinomialRabbits.

Wilensky, Uri, Center for Connected Learning and Computer-Based Modeling, Northwestern University.
Central Limit Theorem Model.
http://ccl.northwestern.edu/netlogo/models/CentralLimitTheorem.

Student Activities

Graphical Methods for Describing Univariate Data

(Adapted from a project attributed to Susan Mead, in Christopher R. Olsen, *AP Statistics Teacher's Guide* [New York: College Board, 2002], 154.)

You are a dietician who has been asked to make a presentation to a high school class. You would like to discuss the nutritional value of fast food, using the concepts learned in *The Practice of Statistics*, chapter 1. Please do the following:

1. Pick one of the restaurants from the following list and look at one nutritional value (e.g., calories, sodium content, fat content, cholesterol) across all food products (entrees, salads, and sides). If there is more than one size for that product, use the middle size. Using the data shown in the tables, prepare a graphical representation of the nutritional value of the data set with at least 15 values. Then analyze the distribution, including measures of center and spread, the shape, clusters, gaps, and outliers. Write a brief summary of the nutritional value of the fast food from your restaurant.

2. Pick two restaurants. Choose a nutritional value different from the one you chose in problem no. 1. Do a comparison of this value for both restaurants, including graphical and numerical analysis. Are there any differences or similarities between the two types of establishments with regard to the chosen nutritional value?

Please include separate lists of data for each part of this project.

Web sites for the restaurants are given below. If you would like to analyze a fast-food restaurant that is missing from this list, just ask if you may include it.

Burger King	www.bk.com
Chick-fil-A	www.chickfila.com
Church's Chicken	www.churchs.com
Jack in the Box	www.jackinthebox.com
Kentucky Fried Chicken	www.kfc.com
McDonald's	www.mcdonalds.com
Wendy's	www.wendys.com
Whataburger	www.whataburger.com

Grading

This is a 50-point project, equivalent to half a test.

All work is due at the beginning of the period on ______________, *even if you are absent*. There will be a 15 percent per day deduction for late work.

Each project should begin with a cover sheet that includes the title of your project, your name, and the date. Do not put it in a binder. Just staple or paper clip the pages together.

- Summaries should be typed, double-spaced, and in paragraph form.
- Graphs may be on separate pages from your summaries.

- Projects should be grammatically correct and without spelling errors. I will deduct points for offensive errors.
- You may turn in a rough draft before ___________ for me to evaluate.

Point breakdown for grading:

List of data for part 1	2 points
Appropriate display of data for part 1	9 points
Summary for part 1	9 points
Lists of data for part 2	4 points
Appropriate comparative display of data sets for part 2	13 points
Summary for part 2	13 points

The Helicopter Project

(Adapted from the NCSSM Web site: http://courses.ncssm.edu/math/Stat_Inst/PDFS/FacDesgn.pdf)

Group members: (names and contact information):

________________________ ________________________

________________________ ________________________

________________________ ________________________

________________________ ________________________

For this project, we will investigate the flight of helicopters (made from cardstock) launched from the second floor of Mayde Creek High School. We want to see if there is a difference between launching helicopters with a longer or shorter blade. We will also look to see if there is a difference between using one or two weights (paper clips). Once agreement is reached by the entire class as to what will constitute the "best flight," each group will develop and perform its own experiment to determine the best combination of rotor length and added weight. The first trial is a "rough draft" day so that individual group members can compare their conclusions and develop one report for each group. You will have 20 helicopters to use for the experiment, plus 4 for the trial run. Tape measures and stopwatches will be available, if needed.

First-Day Worksheet

Answer/define the following questions/terms for your group:

1. The explanatory variable(s)
2. The response variable—how will you measure this?
3. The experimental units
4. The factor(s) and level(s)
5. How many treatments?

6. What type of design will be used?
7. Draw the design:
8. What **controls** do you need? Be specific:
9. State the procedure your group will use to do the experiment. BE PRECISE!! Assign group members to do the different jobs.
10. Assign the helicopters to treatments. Explain how your group did this.
11. Perform trial runs. Make corrections or improvements to your answers for the questions above.

Second-Day Worksheet

As a group, answer these questions when you finish your experiment. You will finalize your comments/thoughts in your group report.

1. What are the results for each helicopter?
2. What are the mean and standard deviation for each treatment?
3. What conclusions can be drawn from your data?
4. Did anything go wrong? If so, what?
5. What would you and your group do differently?
6. Draw a double line graph (one line for the longer rotor, one for the shorter) of the means of each treatment, putting the measurement of flights on the vertical axis.

Grading

The report that each group submits should consist of the following parts and must include this sheet for each group member. Your grade is based on the following (maximum possible points are in parentheses):

Points

__________ Abstract of experiment (10)

__________ Randomization method and list of helicopters assigned to treatments (5)

__________ Controls (10)

__________ Procedures (10)

__________ Raw data and exploratory analysis (10) (does not need to be typed)

__________ Double line graph (10)

__________ Interpretation of results (10)

__________ What would you do differently? (5)

____________ First-day worksheet from each group member (10)

____________ Cooperative work (group/teacher evaluation) (20)

____________ Project grade (100)

Confidence Intervals and Significance Tests Portfolio

Each year, I provide students with a set of problems that examines, in addition to the tests and intervals, all of the important concepts, including conditions that are violated, questions regarding Type I and II errors, sample size needed for a particular size interval, references to cause and effect, and so forth. Each student creates an individual portfolio and receives credit for each submission (graded on a 5-point scale). Students are given the opportunity to correct or improve these examples before the final submission. When all of the items have been completed, the portfolio is used to answer several in-class problems. Two of the original problems are also randomly selected to determine if they have been corrected or improved to “perfect 10s.”

- There are 10 examples to complete.
- All work must be *neatly* shown, with a full summary and explanation.
- The portfolio should include this cover page and be in a three-ring folder/notebook.
- The portfolio counts as the equivalent of one test grade, and problems are graded according to the following criteria:
  - Completion/correctness on specified due dates
  - Correctness at the conclusion of the project

1. One-sample z (completed) ____________(5)
2. One-sample t (completed) ____________(5)
3. Matched pairs t (completed) ____________(5)
4. One-sample proportion z (completed) ____________(5)
5. Two-sample t (completed) ____________(5)
6. Two-sample proportion (completed) ____________(5)
7. Chi-square goodness of fit (completed) ____________(5)
8. Chi-square homogeneity (completed) ____________(5)
9. Chi-square independence (completed) ____________(5)
10. Lin-reg slope (completed) ____________(5)

- -

11. Notebook, cover sheet, and neatness ____________(10)
12. Random problem (corrected) ____________(10)

13. Random problem (corrected) ____________(10)

14. In-class problem(s) ____________(20)

Total: ____________(100)

Game of Chance

After the AP Exam, we usually have two weeks of class before final exams start, and because some of my students are taking other AP Exams, I do not want to burden them with additional homework or makeup work. The Casino Lab activity from the *Golden Resource Binder* (2nd ed.) for chapter 7 of our text is used to introduce games of chance. Additional history for each game is also discussed. After completing the lab, students must create their own game of chance. Partners may be used if desired. Students must create a sheet for documentation of game results when played by their classmates. Often additional texts must be referenced to determine the theoretical probability of the new game. This has proved to be an entertaining way to finish the year!

Instructions

After having looking at several popular games of chance, it is now your turn to develop your own game using probability. You may work alone or with one partner. The following requirements must be met:

<u>Step One</u>:

1. Decide on a game that you would like to develop.
2. Test your ideas through simulations of your game.
3. Are you able to answer all of the questions in step two for your game?
4. Adjust/change the rules and guidelines for your game.
5. Share your thoughts with Mrs. Daniluk before proceeding.

Proposal acceptance date: ____________________

<u>Step Two</u> (prepare your written project, including each of the following):

1. Name your game. (5 points)
2. Describe the rules of your game. (10 points)
3. Play your game, **recording the results**, and determine the experimental probability of winning. "Playing of your game" may be done with the actual materials or simulated with the calculator. Play a realistic number of times in order to feel somewhat confident about your experimental probability. (5 points)
4. Determine the theoretical probability of winning your game. This may be much more difficult than it sounds, so think about this aspect of your game as ideas grow. Of course, your work must be shown! (10 points)
5. If it costs $2 to play your game, what must the payoff be in order to make this a fair game? (5 points)

6. Find two other individuals from our class to play your game. Provide them with the proper forms or worksheets to record their results. (5 points)

7. How do these results (in item 6) compare with the experimental and theoretical probabilities that you found in items 3 and 4 above? (5 points) Is there a substantial difference? (5 points)

8. Are there any improvements or alterations that you think should be made to your game?

Grading

This assignment counts as a 50-point quiz, or you may double the points to make it equivalent to a 100-point test—whichever you prefer.

Note: This will not be decided randomly ☺. Have fun!

Sample Syllabus 6

Jared Derksen
Rancho Cucamonga High School
Rancho Cucamonga, California

School Profile

Location and Environment: Rancho Cucamonga High School (RCHS) is located in a suburban area 40 miles east of Los Angeles. The school has experienced six years of improvement on state tests. There are two student leadership groups—one follows a traditional model by organizing rallies, dances, lunchtime activities, and community projects, whereas the other group, our Renaissance Program, is solely dedicated to promoting and recognizing student achievement. Renaissance works with local businesses and school funds to provide special T-shirts to students on the Honor Roll and recognizes students who show marked scholastic improvement, as well as our academic Top 10. The Renaissance Rally held every spring is viewed by many students as one of the highlights of the school year. RCHS also sponsors more than thirty student clubs, ranging from guitar and chess to various ethnic dancing groups and *anime*. Our award-winning music program has many different ensembles and performing groups, and the athletic program is competitive in the Southern California League. In short, RCHS has a strong sense of school pride and accomplishment and fosters an environment where being involved while learning is highly valued.

Grades: 9–12

Type: Public high school

Total Enrollment: 2,800

Ethnic Diversity: The student body is 34 percent Hispanic/Latino, 16 percent African American, and 7 percent Asian American.

College Record: Although 70 percent of the graduating students go to college, only 30 percent attend a four-year university.

Personal Philosophy

I am enthusiastic about teaching AP Statistics—this is a dynamic class that significantly influences my students' thinking and the way they view the world. I jokingly tell them, "Be forewarned! If you do not want to think about statistics at the most inopportune moments for at least the next five years, don't take this class!" The applications and implications of statistics can be found everywhere in our culture: election polls, medical studies, financial analysis—and even bags of M&M's. For that reason, I always make sure that assignments are tied to real-world data, and class time often includes interactive experiments and activities. My goal is to show students how to think carefully about the collection and analysis of data, thereby helping them to make discerning and rational decisions about many important issues that rely on statistical claims and improving their critical thinking skills in general.

Class Profile

RCHS offers three sections of AP Statistics annually, all taught by me. It is a one-year, two-semester course that meets five days a week. The class is 55 minutes long, except on Fridays, when it meets for 45 minutes. Class size ranges from 25 to 35 pupils per section. Students enter the class with a wide range of backgrounds. Some have the minimum prerequisite (passing Algebra 2 with a "C"), whereas others come from the honors program. It is not uncommon for honors' students to take AP Statistics concurrently with Precalculus or Calculus.

Course Overview

The course includes the topics listed in the *AP Statistics Course Description*, primarily through the use of three resources: Bock et al., *Stats: Modeling the World*, second edition (the main textbook); Levine-Wissing and Thiel, *AP Statistics*, third edition; and the past AP Exam questions available on AP Central, as well as in the AP Statistics Released Exams (1997 and 2002 [Note: The 2007 Released Exam has become available since this syllabus was submitted.]). (For complete citations, see the Teacher Resources section of this syllabus.)

My objectives for the course are that the students learn:

- The material in the Topic Outline of the Course Description
- How to read and analyze surveys and experiments as reported in the media
- How to use technology, both handheld and computers, to analyze data sets, large and small
- How to clearly communicate the results of a study to a small group

The handout below, which I give to the students at the beginning of the year, explains the overall organization of the course.

Expectations

I look forward to teaching every day. I hope that you will come to class ready to learn and with a positive attitude. Statistics is an inherently interesting subject: it surrounds us everywhere we go. Investigating such a fascinating topic will involve lots of participation on your part. So turn off your cell phone, and come to class ready to think and be stretched!

Participation

You are expected to participate in class regularly. Finishing the "Do-Now" problems and completing problems that we work on during class time is essential for your learning. You will turn in participation cards during class to demonstrate how involved you are.

Materials

All students must have the following in class on a daily basis:

- A three-ring binder or spiral notebook
- Your formula sheet in a sheet protector
- Graphing calculator (TI-83 Plus or TI-84 preferred, if purchasing new)

Please talk to me if you need to check out a calculator.

Homework

Homework will be assigned three or four times a week. You are allowed one late assignment for every 10 we complete. Other late assignments may be completed for half credit.

After-School Tutoring and Study Groups
I will be available after school for tutoring one or two days a week. On Mondays, the schedule for the week will be announced. I strongly recommend that you form a study group. Working with your classmates to learn the material is an excellent way to improve your understanding of statistics.

Course Planner

The numbered weeks below indicate actual instruction time, exclusive of school breaks and holidays. Full citations for all sources mentioned here can be found in the Teacher Resources section of this syllabus.

SEMESTER 1

Unit I: Exploring and Understanding Data
Stats, chapters 1–6
Time frame: five weeks

Week 1

- Introduction to stats (chapter 1)
- What is data? (chapter 2)
- Describing and displaying categorical data (chapter 3)
- Introductory discussion of independence (chapter 3)

Workshop Statistics (Rossman et al.), activities 1-1 through 1-6
Activity: M&M dotplots with description

Week 2

- Describing and displaying quantitative data (chapter 4)

Quiz on chapter 4

Week 3

- Summary statistics for quantitative data (chapter 5)
- Outliers (chapter 5)

Workshop Statistics, activity 3-1
Quiz on outlier rule and describing/comparing quantitative data
Favorite released AP Exam free-response questions to use:

- 1997, no. 1
- 2000, no. 3
- 2001, no. 1
- 2002 Form B, no. 5

Week 4

- The normal distribution (chapter 6)
- The effect of linear transformations to data sets on summary statistics (chapter 6)

Week 5

- Review and assessment of Unit I

Unit I vocabulary crossword
Project 1: Exploring data—collect data, graph it, and describe it (see the Student Activities section of this syllabus)

Unit I Exam

A major test is given at the end of this unit. It includes at least one AP Exam free-response question (see list in week 3) and is given on one-and-a-half school days. The test has multiple-choice problems as well.

Unit II: Regression

Stats, chapters 7–10
Time frame: four weeks

Week 6

- Displaying and describing scatterplots (chapter 6)
- Analyzing two-variable quantitative data
  - Correlation and the coefficient of determination (chapter 7)

Workshop Statistics, activities 8-1 and 8-2
Quiz on describing scatterplots

Week 7

- Analyzing two-variable quantitative data
  - Least-squares regression (chapter 8)
  - Slope and *y*-intercept (chapter 8)

Week 8

- Analyzing two-variable quantitative data
  - Residuals and residual plots (chapter 8)
  - Outliers and influential points (chapter 9)

Unit II vocabulary crossword (see the Student Activities section)
Analysis of the Anscombe data set
Megaquiz on regression (after chapter 8)
Stats wandering point worksheet (from *Printed Test Bank and Resource Guide*)
Favorite released AP Exam free-response questions to use:

- 1999, no. 1
- 2002, no. 4
- 2002 Form B, no. 1
- 2003 Form B, no. 1

Week 9

- Transformations to achieve linearity (chapter 10)

Favorite released AP Exam free-response questions to use:

  - 1997, no. 6
  - 2004 Form B, no. 1

Unit II Exam

This major exam includes regression (again) and the topics in chapters 9 and 10.

Unit III: Collecting Data

Stats, chapters 12–13
Time frame: three weeks

Week 10

- Designing surveys via various methods (chapter 12)
- Bias in surveys (chapter 12)
- Randomization and representative samples (chapter 12)

Workshop Statistics, activities 12-1 and 12-2
Project 2: Bias in surveys (see the Student Activities section)

Weeks 11 and 12

- Observational studies (chapter 13)
- Experimental design (chapter 13)
  - Control
  - Random assignment of treatment
  - Replication
  - Placebo and blinding
  - Blocking and matched pairs
  - Confounding and lurking variables
  - Statistically significant difference (introduction)

Workshop Statistics, activities 13-1 and 13-2
Unit III vocabulary crossword (see the Student Activities section)
Stratification activity (North Carolina School of Science and Math [NCSSM] Web site)
Favorite released AP Exam free-response questions to use:

  - 1997, no. 2
  - 1999, no. 3
  - 2001, no. 4
  - 2002, no. 2
  - 2002 Form B, no. 3
  - 2003, no. 4

Unit III Exam

In addition to 10 multiple-choice questions, the test contains 3 free-response questions that are similar to those found on the AP Exam.

Unit IV: Probability

Stats, chapters 11, 14–18
Time frame: eight weeks (the last six weeks of the first semester and the first two weeks of the second semester)

Week 13

- Basic probability principles, including complementary, independent, and mutually exclusive events (chapter 14)

Examination of homemade dice data: law of large numbers

Week 14

- Addition, multiplication, and conditional probability rules (chapter 15)

Scramble worksheets assigned (worksheets that consist of a mixture of different probability chapters)
Probability quiz
Favorite released AP Exam free-response question to use:

  - 2003 Form B, no. 2

Week 15

- Random variables (chapter 16)
  - Expected value and standard deviation
  - Rules for transforming and combining random variables

More scramble worksheets
Unit IV vocabulary crossword
Favorite released AP Exam free-response questions to use:

  - 2001, no. 2
  - 2002 Form B, no. 2
  - 2004, no. 4

Probability test: chapters 14–16

Week 16

- Simulating probability scenarios (chapter 11)

Favorite released AP Exam free-response question to use:

  - 2001, no. 3 (or a variation that examines whether iPods® really shuffle randomly!)

Week 17

- Review for final exam

Week 18

- Finals week: cumulative semester exam

SEMESTER 2

Unit IV: Probability (continued)

Week 1

- Binomial and geometric distributions for means and proportions (chapter 17)

Continue to use simulations from chapter 11 to examine this topic
Quiz

Week 2

- Sampling distributions (chapter 18)

Sampling distributions activity using beads of two different colors
Sampling distribution applet used for demonstration
Test: chapters 17 and 18

Unit V: Inference for Proportions

Stats, chapters 19–22
Time frame: four weeks

Week 3

- Confidence intervals for one proportion (chapter 19)

Use beads of two different colors to estimate proportions
Quiz on confidence intervals

Week 4

- Hypothesis testing for one proportion (chapter 20)

Short test on tests and intervals

Week 5

- Type I and II errors and power (chapter 21)

Colored bead activity from "mystery" bags (analysis of errors and power)
Unit V vocabulary crossword
Unit V exam (chapters 19–21, including review of sampling distributions for proportions)

Week 6

- Intervals and tests for two proportions (chapter 22)

Cumulative Unit V Exam

(Chapters 19–22)

Unit VI: Inference for Means

Stats, chapters 23–25
Time frame: three weeks

Week 7

- Confidence intervals and hypothesis tests for one mean (chapter 23)

Examination of homemade dice (mean = 3.5?) Students will not know whether their die, because it is homemade, will have a mean of 3.5 or not. A fair die should.
Quiz on *t* procedures

Week 8

- Confidence intervals and hypothesis testing for two means (chapter 24)

Unit VI vocabulary crossword
Exam on one- and two-sample *t* procedures

Week 9

- Confidence intervals and hypothesis testing for matched pairs means (chapter 25)

Cumulative Unit VI Exam

Unit VII: Inference for Counts and Slope

Stats, chapters 26–27
Time frame: two weeks

Week 10

- Chi-square goodness of fit (chapter 26)
- Chi-square for homogeneity and for independence (chapter 26)

Test homemade dice for fairness

Week 11

- Confidence interval for slope (chapter 27)
- Hypothesis testing for slope (chapter 27)

Unit VII vocabulary crossword

Unit VII Exam

This includes regression review questions.

Review for the AP Exam

Time frame: four weeks

- Various book exercises
- Practice free-response problems
- Practice work from *AP Statistics* (Levine-Wissing and Thiel)

Assessment

As we review the course, free-response questions are given as quizzes. These free-response scores are accumulated to generate a practice test score. I also give a practice multiple-choice exam.

Cumulative Project

Time frame: four weeks

- Cumulative year-end project (see the Student Activities section at the end of this syllabus)

Assessment

The final project receives a grade.

Teaching Strategies

I firmly believe that it is important for students to take an active role in their own learning process, not just to be passive sponges soaking up isolated pieces of information. Their immersion in the subject by working both independently and together in class on a variety of problems and projects helps them to consolidate what they have gleaned from the textbook and from listening to me. Moreover, it spurs them to think for themselves, to make critical judgments about statistical claims they encounter every day, and to consider novel applications for the methods they have learned. In order to engage them in this sort of challenge, I use a number of different approaches—among them, the following:

- Data is frequently collected from the class. On the first day, students fill out a short questionnaire, and these data are used throughout the first unit. Many topics are introduced by asking students to provide simple information about themselves, and the resulting data are used to open the day's lesson.
- I use "participation cards" in class to encourage active learning. Whenever a student participates in any class activity (answering questions, offering solutions, doing work on the board, and so forth) that person (along with any other student who helped with the answer) hands me a card with his or her name on it. These cards are then tabulated as a part of each student's grade.
- Every other week students read current news articles that contain statistics and/or statistical issues and summarize them. These articles are then discussed in class. Sources are available everywhere on the Internet—the AP newswire, online newspapers, and popular Web sites. Two good examples are stories about a survey of the survivors of the 2004 tsunami in the *Washington Post* (www.washingtonpost.com/wp-dyn/articles/A10689-2005Jan14.html) and about "smart baby" DVDs at WebMD (http://children.webmd.com/news/20070807/smart-baby-dvds-no-help-may-harm).
- A classroom set of *Workshop Statistics* is used for occasional cooperative group work.
- When studying inference, students do confidence intervals and hypothesis tests on a template sheet that walks them through the necessary steps: name, hypotheses (tests only), check of conditions, formulas and math work, and conclusion. They use this template throughout the inference units and even on many of the assessments. During review time for the AP Exam, they are weaned from the template, but by then the steps for inference have become automatic.
- When we finish the course with a final project after the AP Exam, students learn the use of *Data Desk*® computer software. I have designed a series of four lessons that guide them through the basics of using the program:
  - Lesson 1—Descriptive Statistics (graphs and summary reports)
  - Lesson 2—Regression (using scatterplots and regression tools)
  - Lesson 3—Inference (performing hypothesis tests and confidence intervals)
  - Lesson 4—Large Data Sets (students are given large data sets and asked to analyze them)

  Students are then encouraged (as technology at school and home permits) to use *Data Desk* to analyze their final project.

Student Evaluation

Students receive two separate grades for each semester of the course. In order to help students and the instructor remain focused on the thorough learning of each component of the course, all assessments are sorted by unit. A typical grade breakdown is as follows:

First Semester		Second Semester	
Homework	10 percent	Homework	10 percent
Participation	10 percent	Participation	10 percent
Unit I	25 percent	Unit IV (end)	10 percent
Unit II	20 percent	Unit V	20 percent
Unit III	15 percent	Unit VI	15 percent
Unit IV (beginning)	20 percent	Unit VII	10 percent
		Review for AP Exam	15 percent
		Final project	10 percent

I do not put tests and quizzes in a separate category. Any assessment the student takes goes into the unit to which the material pertains. The first-semester final exam grade is broken into four parts—one part for the questions on each unit. This grading system has the advantage of making it easier to recognize and reward progress over time. For example, if a student earns high marks on the regression questions on the first-semester final exam, these scores can be compared with the grade in the Unit II category and a more appropriate grade for the student's level of comprehension can be assigned.

Students are highly encouraged to take the AP Exam. They are reminded that high-stakes exams are common in college, so taking an AP Exam is a good way to practice for these upcoming assessments.

Teacher Resources

Basic and Supplementary Textbooks

Bock, David E., Paul F. Velleman, and Richard D. De Veaux. *Stats: Modeling the World*. Boston: Pearson/ Addison-Wesley, 2004. (This is the primary text used for the course.)

Levine-Wissing, Robin, and David Thiel. *AP Statistics*. 3rd ed. Piscataway, N.J.: Research and Education Association, 2006.

Resource Books

Bock, David E., and William B. Craine III. *Printed Test Bank and Resource Guide for "Stats: Modeling the World."* 2nd ed. Boston: Pearson/Prentice Hall, 2007.

College Board. 1997 *AP Statistics Released Exam*. New York: College Board, 1997.

College Board. 2002 *AP Statistics Released Exam*. New York: College Board, 2002. (Note: The 2007 Released Exam has become available since this syllabus was submitted.)

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. 2nd ed. Belmont, Calif.: Thomson Brooks/Cole, 2005.

Rossman, Allan J., Beth L. Chance, and J. Barr von Oehsen. *Workshop Statistics: Discovery with Data and the Graphing Calculator*. 2nd ed. Emeryville, Calif.: Key College Publishing, 2002.

Scheaffer, Richard L., Mrudulla Gnanadesikan, Ann Watkins, and Jeffrey A. Witmer. *Activity-Based Statistics*. New York: Springer, 1996.

Yates, Daniel S., David S. Moore, and Daren S. Starnes. *The Practice of Statistics: TI-83/89 Graphing Calculator Enhanced*. 2nd. ed. New York: W. H. Freeman, 2003.

Software/Multimedia

ActivStats. CD-ROM ed. 2000–2001 release. By Paul Velleman. N.p.: Addison-Wesley, 2000. *Data Desk* is the analysis software that is built into *ActivStats*.

Web Sites

AP Central.
apcentral.collegeboard.com.
I use this site regularly as a source of free-response questions other than those published in the Released Exams.

Claremont Graduate University, WISE Project's Statistical Power Applet. Type I and II and power applet.
http://wise.cgu.edu/power/power_applet.html.

Eclipse Crossword.
www.eclipsecrossword.com.
Generates crossword puzzles from a list of words and clues.

Geometer's Sketchpad Resource Center.
www.dynamicgeometry.com/javasketchpad/gallery/pages/least_squares.php.
Least-squares regression demonstration.

NCSSM Statistics Leadership Institute. An Exercise in Sampling: "Rolling Down the River."
http://courses.ncssm.edu/math/Stat_inst01/PDFS/river.pdf.
Stratification activity

Stanton, Charles. California State University, San Bernadino.
www.math.csusb.edu/faculty/stanton/m262/regress/regress.html.
Linear regression influential point applet.

University of Illinois at Urbana–Champaign, Department of Statistics. "Guess my correlation" applet.
www.stat.uiuc.edu/courses/stat100//java/GCApplet/GCAppletFrame.html.

Student Activities

Project 1: Exploring Data

<u>Purpose</u>

To practice describing data and graphs and to *begin* to think about data collection and sources of bias.

Page 1 (must be typed)

First paragraph:	Describe how and where you collected your data (collect at least 25 data points; data must be quantitative).
Second paragraph:	Do you think your data represent the population you were studying? Why or why not? What sources of bias do you think may have been present in your data collection?
Third paragraph:	By studying graphs of the data, what relationships can be observed? What do the graphs show? What conclusions can be drawn?

Page 2 and following

Graph your data.

- By hand, neatly, is fine.
- Make *two* different types of graphs for the quantitative data—histogram, boxplot, stemplot, and/or dotplot.

Note: *Excel* makes great pie graphs and lousy histograms—proceed at your own peril.

Project 2: Bias in Surveys

Purpose

To investigate how much different forms of bias can affect the results of a survey.

The Project

- The project must be done in groups of one to four. Submit one poster per group.
- A brief oral presentation is also required for each group. *No written report is necessary.*

Topic

You will design a survey on an interesting topic of your choice, but you must design it so you can address *one* of the following questions:

- Is it possible to word a question in two different ways that are logically equivalent but that produce much different responses?
- Do the characteristics of the interviewer affect responses?
- Does anonymity change the responses to sensitive questions?
- Does providing extra information affect the responses?

Note: You may choose another form of bias if you get special approval from me.

You should compare at least two different groups. Usually this consists of a “control” group that is “normal” and unbiased and a second group that is biased in a certain direction. Depending on your idea, you may choose to have two different biases—one that will tilt in one direction and one that will tilt in another. You will not be penalized if you do not succeed in creating a large bias.

Proposal

Each group's project proposal should include the following:

- A definition of the population
- A copy of the survey questions
- A short description of how you will create bias and what direction you think the bias will swing
- Where and how you will collect your data

Note: Your sampling procedure should *not* be biased. Survey 50 people per question (50 for the unbiased question, 50 for each biased question).

Poster

The poster should completely summarize your project yet be simple enough to be understood by someone unfamiliar with statistics. Remember the purpose of the project! It should be pleasing to the eye. It should include a one-page typed summary describing what you did. The colors on your graphs are crucial to communicating the bias being examined: use a consistent color key so the change can be easily spotted.

Points: 30 points (10 for appearance, 10 for clear communication on graphs, 10 for the summary)

Oral Presentation

All group members must participate equally in this five-minute talk, and your poster should be used only as a visual aid. To receive full credit for the presentation, your group must speak clearly and with confidence, and you must do something to *engage the audience*. I leave it open-ended as to exactly what you tell us about what you did, but I absolutely insist that your presentation be clear, interesting, and articulate. Your task is to be verbally engaging—we do not have time for elaborate props/media setup.

Points: 20 points (10 for being stimulating, 10 points for clear communication)

Due Dates

- Proposal: Tuesday, November 14
- Poster: On your presentation date, between December 4 and December 15
- Your group will be randomly assigned a presentation date. If your group is not ready and/or does not have 100 percent attendance on that day, you will be moved to a different date and receive a 20 percent penalty on your presentation grade.

Cumulative Year-End Project

Report Proposal

Due: Friday, May 12

- The question of investigation/curiosity:

- Population of interest:

- A brief description of how and where you are going to collect your data:

Difficulty/Interest Rating: ________ (to be completed by me)

I. Data Report (20 points)

Due: Wednesday, May 25

This section should be a thorough explanation of how you collected your data and be a beautiful example of how much you have learned this year about the difficulties of getting a representative sample. Examples of what you should include follow:

- How you collected your data
- Why you are confident your sample matches your population
- Biases avoided and not avoided
- A copy of any survey that was filled out
- Your data, either in *Excel* format or in a table/matrix summary. You need at least 75 people/subjects for *each* group you want to compare. Your data should be broken up by any category you want to compare.

II. Exploring the Data (25 points)

Due: Friday, June 2

This section should be an outstanding example of exploratory data analysis (the first unit in our text). Graphs should show comparisons between all relevant groups. You should state any preliminary conclusions that can be drawn from visually obvious patterns. Be sure to include the following:

- Graphs of your data
- Statistics from your data
- Descriptions of the graphs and statistics

Extra credit will be earned for using *Data Desk*.

III. Analyzing the Data (25 points)

Due: Wednesday, June 7

Analyze your data, using whatever method(s) are appropriate. Your conclusion should be clearly written, using all appropriate statistical support. Remember that confidence intervals can be a powerful method for comparing different groups. This analysis should include the following elements:

- Hypothesis test (with conditions checked) and/or
- Confidence intervals (with conditions checked) and/or
- Regression
- Your grand conclusion!

Extra credit will be earned for using *Data Desk*.

IV. Presentation (20 points)

Due: Friday, June 9

The requirements for the groups' oral reports are given below:

- Clearly communicate your question and how you collected your data (5 points).
- Visually display graphs of your data—*PowerPoint* (if you must), overhead, poster, or video (5 points). I *do not* want a pretty poster that summarizes the whole project. I want you to make a visual aid that shows the class how your data came out. There should be only minimal text on your visual aid—titles and big numbers—not any explanations.
- Clearly communicate your conclusion (5 points).
- Be interesting to listen to and give us some sort of "hook" to inspire us to listen (5 points).
- Do *not* read from your visual aid—use note cards or your report. Be careful how you communicate numbers to the class—too many numbers at once are confusing, as is giving too many decimal places.

V. Success!? (15 points)

I will evaluate the overall success and difficulty of your project. More challenging data collection issues add to your score. Small sample sizes or an overly simple question will lower your score.

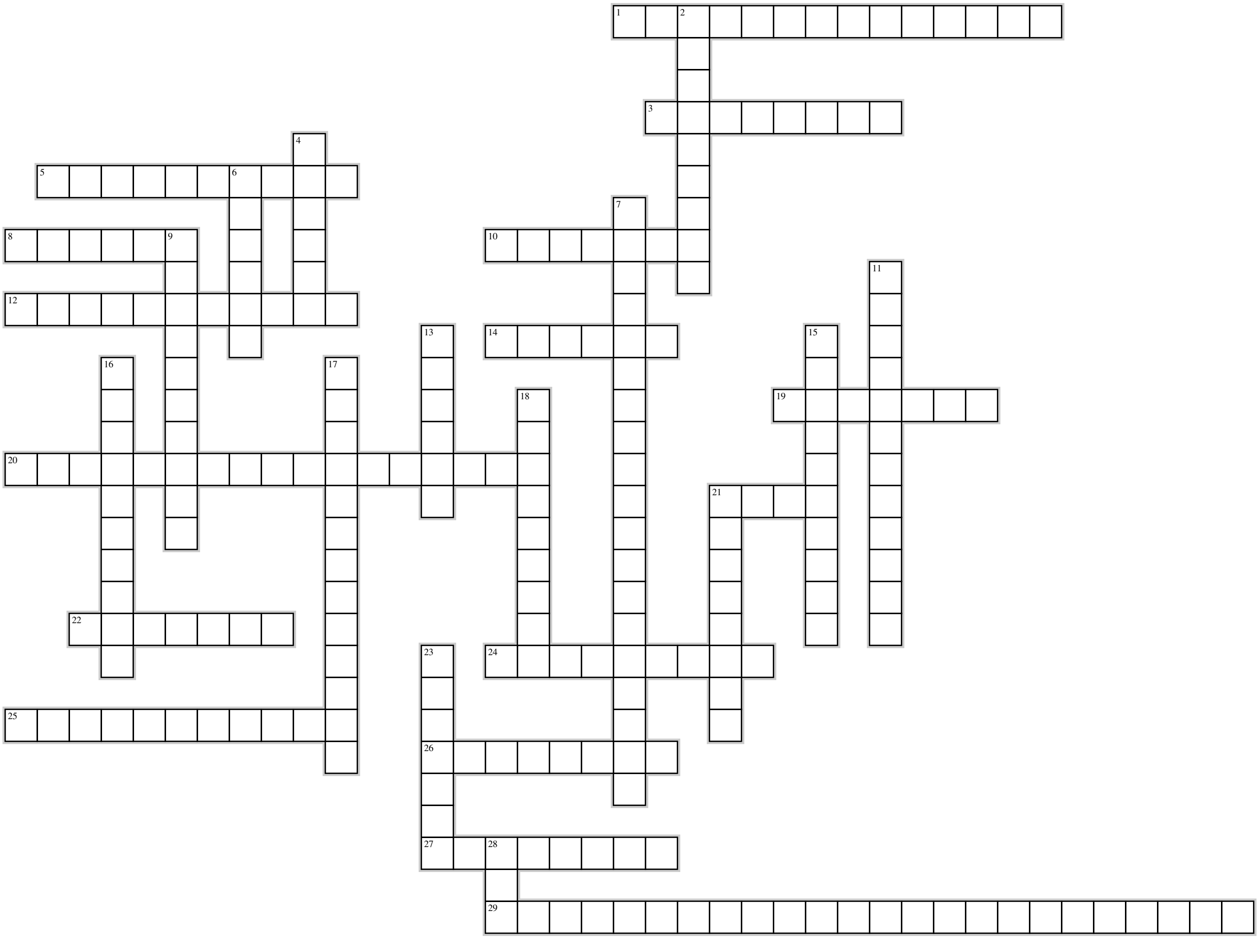
General Requirements

- Make your own copies of the data, graphs, and so forth. Once you turn in each part of your report, I need to keep it.
- Do not get lazy—this is to be the summation of what you have learned all year.
- Please type your paper. Handwritten work is acceptable for some graphs and the like, if it is done very neatly.
- Your work should be thorough and competently written. Bullet points may be used to delineate a list of observations. Clear communication and thorough analysis is necessary for full credit.

Vocabulary Crosswords

On the following pages is a crossword puzzle that I created with Eclipse Crossword (www.eclipsecrossword.com).

Chapter 3

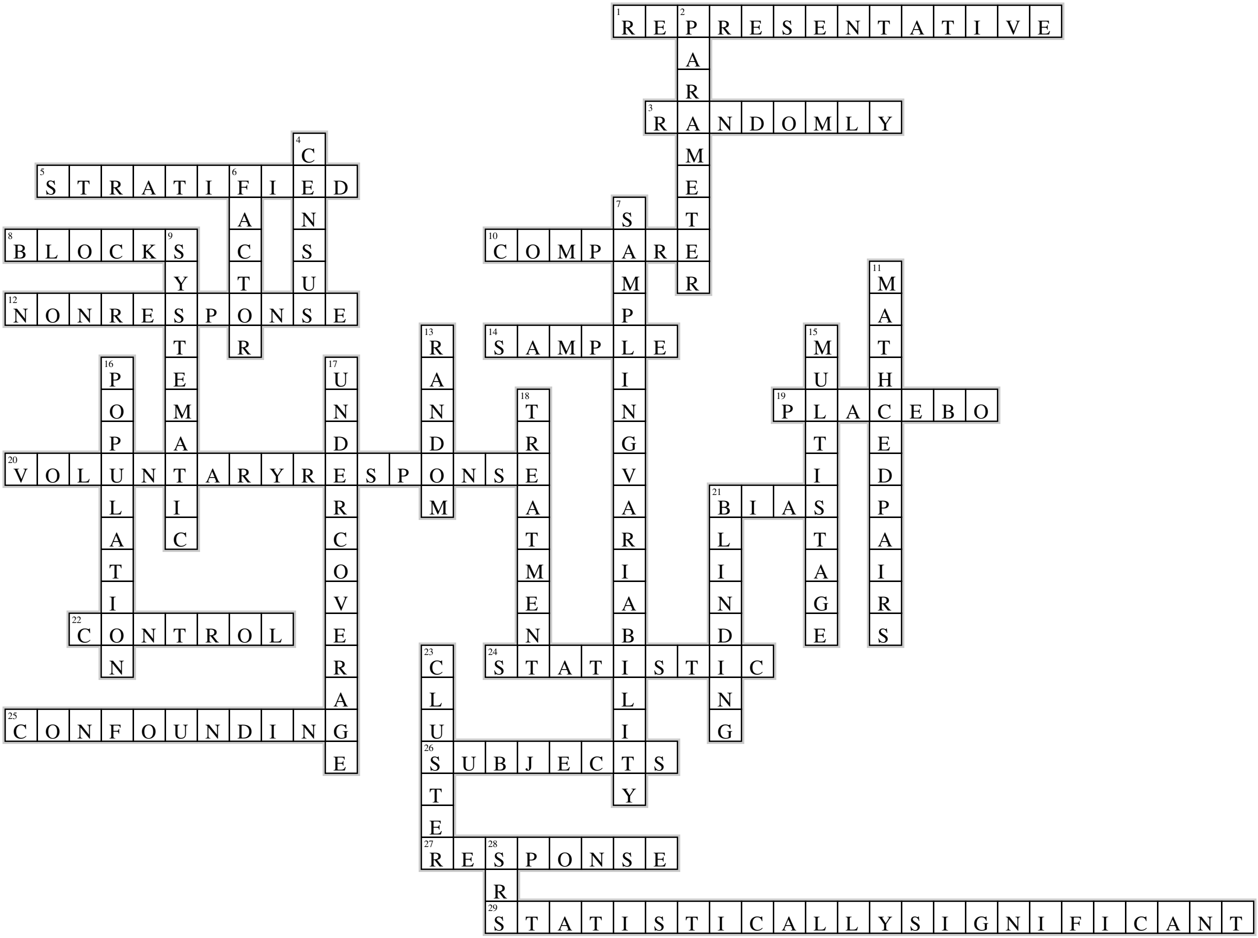


Across

1. **REPRESENTATIVE**—If the sample looks like the population, then it is ____.
3. **RANDOMLY**—We assign the treatments to the subjects ____.
5. **STRATIFIED**—When I divide the population into homogenous groups and choose randomly from each, this is a ____ random sample.
8. **BLOCKS**—We divide subjects into groups that will respond similiarly to the treatments called ____.
10. **COMPARE**—At the end of the experiment, we ____ the treatment groups.
12. **NONRESPONSE**—Bias created because some people refuse to participate in the survey
14. **SAMPLE**—The small group from which we get data
19. **PLACEBO**—A sugar pill
20. **VOLUNTARY RESPONSE**—When those surveyed get to choose if they want to respond
21. **BIAS**—To systematically favor certain outcomes
22. **CONTROL**—The group that does the status quo for purposes of comparison is the ____ group.
24. **STATISTIC**—A value that I get from my sample/data
25. **CONFOUNDING**—When two variables are intertwined so I cannot determine their effects, they are ____ variables.
26. **SUBJECTS**—We assign treatments to the ____.
27. **RESPONSE**—Anything that biases the responses of those surveyed is a ____ bias. (Interviewer's appearance, wording . . .)
29. **STATISTICALLY SIGNIFICANT**—If the difference between two statistics is more than chance variation would explain, the difference is . . .

Down

2. **PARAMETER**—The value of the population I am trying to estimate
4. **CENSUS**—I try to survey the entire population.
6. **FACTOR**—The variable the experimenter controls is the ____.
7. **SAMPLING VARIABILITY**—The natural variability that occurs from sample to sample
9. **SYSTEMATIC**—I survey every 10th person who walks by. This is a ____ sample.
11. **MATCHED PAIRS**—An experimental design where every subject does both treatments.
13. **RANDOM**—We know all the values, but cannot predict what will happen next. This is ____.
15. **MULTISTAGE**—A combination of various sampling methods is a ____ sample.
16. **POPULATION**—The entire group of individuals we want to learn about
17. **UNDERCOVERAGE**—Bias created because there are people whom I never survey
18. **TREATMENT**—In an experiment, we apply a ____.
21. **BLINDING**—Keeping someone unaware of what treatment they are using and/or administering
23. **CLUSTER**—When I sample by surveying entire, convenient, heterogeneous groups, it is a ____ sample.
28. **SRS**—I randomly choose from the population to take my survey.



EclipseCrossword.com

Sample Syllabus 7

Jeane Swaynos
Seminole High School
Sanford, Florida

School Profile

Location and Environment: Seminole High School, a suburban school rich in tradition, is located in central Florida, about 60 miles north of Walt Disney World. Sanford is a long-established community that prides itself on its history and family values. This 100-year-old school is the oldest of the eight county high schools, and a large percentage of the faculty are also Seminole High alumni. Seminole High is the only magnet high school in the county with an International Baccalaureate Program as well as an Academy of Health Careers. As a result, more than 700 students come from other areas of the county to be a part of these programs. We also have approximately 1,100 students who are below grade level and therefore in remedial reading and/or math courses. English is the second language in about 13 percent of the homes; approximately 38 percent of the student body qualifies for free or reduced-fee lunches; and our students have close to a 30 percent mobility rate.

Grades: 9–12

Type: Public high school

Total Enrollment: 3,100

Ethnic Diversity: Our student body is 23 percent African American, 17 percent Hispanic/Latino, 7 percent Asian American, and 5 percent multiracial

College Record: About 30 percent of the graduates go on to college.

Personal Philosophy

I believe that every student can learn and apply some parts of the AP Statistics objectives. It is important that students see the relevance of this course in their daily lives. My primary goal is to give them the tools necessary to read critically when making decisions and to make those decisions based on sound statistics. Another significant aim of this class is to show students the wide variety of practical applications of noncalculus-based mathematics. Often students see themselves as poor mathematicians because they struggle with precalculus and calculus. Statistics shows them another branch of mathematics and opens them up to the possibility that there are many other avenues to take when furthering their mathematical knowledge.

Class Profile

AP Statistics has been taught at Seminole High since 1999, with two or three sections offered each year, all taught by me. Each class typically has between 20 and 25 students. We operate on a seven-period day, with all classes meeting five days a week for 49 minutes, except for Wednesday, which is a shorter day with only 40 minutes per class.

AP Statistics classes are composed of a mixture of students, equally divided between two types. In the first group are highly motivated students who are enrolled in Pre-IB courses and take AP Statistics as an elective. Others are sophomores who are enrolled in Precalculus as well. We also have a number of seniors who have completed AP Calculus BC and are taking this subject as another elective.

The second group is made up mainly of seniors, some of whom have never taken an AP course before and who have completed no math course beyond Algebra 2. Some have a weak reading level or poor study skills, and enrolling in an AP class exposes them to the work necessary to be successful in college. The Health Academy students often sign up for AP Statistics because they see a need for this subject in their field.

A majority of students have part-time jobs, working on average 20 hours a week. Keeping everyone engaged in the learning process has been a challenge.

Course Overview

The AP Statistics course at Seminole High incorporates the curriculum set forth in the Topic Outline of the *AP Statistics Course Description* in the order presented by the textbook that I use: *The Practice of Statistics* (second edition) by Yates, Moore, and Starnes. There are four quarterly grading periods, each nine weeks long. The first semester runs from August through January, and the second, from February through June. All AP Statistics students are required to take the AP Exam. This exam is funded by the state of Florida, and students taking an AP course get a weighted grade of 1.0 for the class. Students must maintain a "C" for the weighted grade and are required to take the end-of-year state assessment.

There are computer labs on campus, but reading students and low-level classes are given first priority for these facilities. The statistics class has access to the lab about once every nine-week period. All students have a TI-83 or equivalent calculator that they use at home and in school. Students are loaned calculators for the year if they are not able to afford one. This service is free of charge and available to all students in Algebra 2 or above.

One of our school's goals is to increase enrollment in AP courses. The administration is more concerned with enrollment in the classes than with the students' grades on the AP Exam. The faculty and administration want to expose students to higher-level courses and therefore will accept a wide range of student abilities in AP courses. Studies show that students who take AP courses are more successful in college than those who have not had this opportunity. There are no prerequisites listed for the courses—only suggested recommendations. For AP Statistics, that is completion of Algebra 2. There are, however, some advanced IB students who take Algebra 2 concurrently with AP Statistics, and if they work hard, they are successful.

My specific objectives for this course are that the students acquire the following skills:

- They know the basic concepts presented in the Course Description.
- When explaining statistical concepts, they understand the importance of using clearly defined terms that show an intuitive understanding of these concepts.
- They are able to apply statistical concepts when collecting information and make informed decisions using statistics accurately.
- They develop an appreciation for the depth of understanding that statistics add to real-life situations and understand how statistics could be used to help visualize and add mathematical facts to subjective situations.

Course Planner

The following abbreviations and short titles are used to indicate source material: *ABS* = *Activity-Based Statistics* (Scheaffer et al.); *APS* = *AP Statistics* (Bohan); *DTD* = *Statistics: Decisions Through Data* video (COMAP); *FF* = *Fifty Fathoms* (Erickson); FRQ = AP Exam free-response question from past exams (AP Central and the printed Released Exams); *ISDA* = *Introduction to Statistics and Data Analysis* (Peck et al.); *PS* (the main textbook) = *The Practice of Statistics*, 2nd ed. (Yates et al.); *SFE* = *Statistics for Experimenters* (Box et al.); *SMW* = *Stats: Modeling the World* (Bock et al.); and *VS* = *Visual Statistics* (Doane et al.). See the Teacher Resources section in this syllabus for full citations.

"Practice" free-response questions are usually graded very generously, and students are allowed to work on them in groups. The questions that are not designated "practice" are done individually and graded more stringently.

Quarter 1 (PS Chapters 1–4)

Day	Topic	Activities and Resources	Homework
1	• Broad definition of statistics • Grading system, structure of the class, and syllabus • What to look for when reading an article that uses statistics	Review class syllabus. Hand out books. **Resources** *DTD*, unit 1: "What Is Statistics?" *ISDA*, "Published Data," pp. 86 and 136 *SMW*, read pp. 2–4	*PS*, read sec. 1.1 and complete the first part of the guided notes. Project: Find an article involving statistics, and write a short summary. Due the day before test 1.
2	• Graphical displays of various distributions • Stem-and-leaf plots	Sec. 1.1: Displaying Distributions with Graphs Define the various shapes of graphs. Define categorical and quantitative variables. Describe the center, shape, and spread of a distribution. Stem-and-leaf plots. **Resources** *DTD*, unit 2: "Stem-and-Leaf Plots" *FF*, demo 2: "Mean and Median," p. 24 *SMW*, p. 52, nos. 15, 16; p. 54, no. 30 *SMW*, read pp. 36–39 *ISDA*, p. 64, no. 3.20	Complete the data sheet. (This asks students to provide general information about their schedules, themselves, and their families for survey purposes.) PS, chap. 1, problem nos. 4–8

Day	Topic	Activities and Resources	Homework
3	• Distribution of univariate data (center, shape, spread) • Skewed distributions • Time plots	**Activity** Using the data collected, construct class histograms using Post-It® notes. **Resources** *VS*, chap. 3: "Shapes of Distributions" *SMW*, read pp. 16–17 *ISDA*, p. 83, no. 3.38	*PS*, chap. 1, nos. 9, 10, 12–14, 16, 18, 19
4	• Tools to create a histogram and a cumulative histogram • Statistical language to describe a distribution	Work in groups on making cumulative distributions. *PS*, nos. 20–23: begin in class. **Resources** *DTD*, unit 4: "Measures of the Center"	*PS*, chap. 1, nos. 15, 17–23 *SMW*, p. 33, no. 26
5	• Boxplots • Five-number summary and data sets • Side-by-side boxplots	**Activity** Make a human boxplot using birthdays. Take pictures of the five-number summary students. **Resources** *ABS*, "Matching Graphs to Variables," p. 12 *DTD*, unit 5: "Boxplots" *SMW*, read pp. 61–62 and 68–69	*PS*, read sec. 1.2 with guided notes; chap. 1, nos. 24–27. *SMW*, pp. 76–78, nos. 20, 28; p. 82, nos. 43, 44
6	• Mean and median of a distribution • Technology to create distributions • IQR and rules for justifying an outlier	Define IQR median and mean of a distribution using student-generated data. Find the IQR and determine if there are outliers. **Activity** On the board have student groups display and describe the data collected from day 2 homework. **Resources** *VS*, chap. 1, p. 19	*PS*, chap. 1, nos. 29–32, 34–36 *SMW*, p. 107, no. 11

Day	Topic	Activities and Resources	Homework
7	• Split stemplot • Effects of changing units on summary measures	Board problems Review any technology problems when making histograms and boxplots. **Resources** *VS*, chap. 3, p. 55; chap. 4, p. 74	*PS*, chap. 1, nos. 41–43 Practice FRQs, 2001 nos. 1 and 6A FRQ, 2001 no. 1
8	• Various ways of describing data: advantages and disadvantages • Finding the standard deviation without technology	Review guided notes for chap. 1. Using five simple data entries, find the standard deviation, working through each part of the formula **Resources** *SMW*, read pp. 83–84 *ABS*, “Capture/Recapture,” pp. 126-29	*PS*, chap. 1, nos. 49–51 Practice FRQs, 2004 no. 1, 2002 no. 1
9	• Technology to find the mean and standard deviation	Students work with partners to find the mean and standard deviation of class-generated data. **Resources** *FF*, demo 4: “Transforming the Mean and Standard Deviation,” p. 28 *WS*, activities 4.12 and 4.13, p. 66; 6.8, p. 98	*PS*, chap. 1, nos. 53–55, 58 Articles are due. FRQ, 1997 no. 1
10		TEST 1 (chap. 1)	*PS*, read sec. 2.1; chap. 2, nos. 1–4
11	• Density curves in relation to a histogram	Review of test 1 Sec. 2.1: Density Curves and the Normal Distribution *PS*, outside activity 2A: Fine-grained Distribution	*PS*, chap. 2, nos. 6–9 Practice FRQs, 2005B no. 1, 2006B no. 1
12	• Normal density curve • 68-95-99.7 rule	Board problems to determine if data are normal	*PS*, read sec. 2.2; chap. 2, nos. 12–14, 18
13	• Standardized normal distribution • Finding the z-score for normal distributions	Sec. 2.2: Standard Normal Calculations **Resources** *DTD*, unit 7: “Normal Curve” *ISDA*, p. 134, no. 4.40	*PS*, chap. 2, nos. 19–24

Day	Topic	Activities and Resources	Homework
14	• Finding the area given the *z*-score • Finding the *z*-score given the area	Use the chart to find the area when given the *z*-score. Use the chart to find the *z*-score when given the area. **Resources** *DTD*, unit 8: "Normal Calculations"	*PS*, chap. 2, nos. 26–29 FRQ, 2002 no. 3A
15	• Normality plots	Board problems: finding *z*-score and area Assessing normality **Resources** *FF*, demo 3: "What Do Normal Data Look Like?" *SMW*, read p. 97	*PS*, chap. 2, nos. 31–33, 35, 38, 39 FRQ, 2003 nos. 3A and 3B
16	• Technology to create a normality plot • Technology to find the *z*-score and/or area	Review guided notes for chap. 2. Use calculator to find the *z*-score and area and to create a normality plot.	*PS*, chap. 2, nos. 40, 41, 46–48 FRQ, 1999 no. 4
17	• Methods for assessing normality	Review chap. 1 with *ABS* activity. **Resources** Flanagan-Hyde, "Is It Normal?" (AP Central)	Read "Is It Normal?"
18		TEST 2 (chaps. 1 and 2)	*PS*, read sec. 3.1; chap. 3, nos. 1–4, 6
19	• Scatterplots: definition, interpretation, and analysis of patterns	Review of test 2 Sec. 3.1: Scatterplots Response and explanatory variables **Activity** Plant project (see the Student Activities section of this syllabus) **Resources** *DTD*, unit 11: "Scatterplots" *SMW*, read pp. 116-17	*PS*, chap. 3, nos. 9, 10, 12

Day	Topic	Activities and Resources	Homework
20	• Linear regression (plant project) • Bivariate data: finding the correlation and linearity of the relation	**Activity** Work in groups to organize the plants and complete the project. Write reports following a rubric. **Resources** *SMW*, read pp. 127-29	*PS*, chap. 3, nos. 15–18
21	• Least-squares regression line using a graphing calculator • Correlation and coefficient of determination using a graphing calculator • Residual of a data point	**Resources** *FF*, demo 6: "Least Squares Linear Regression," p. 34 *FF*, demo 8: "Devising the Correlation Coefficient," p. 38 *VS*, chap. 18: "Visualizing Regression Models," p. 353	*PS*, chap. 3, nos. 21–23, 25, 28, 29, 32
22	• r^2 and the correlation coefficient in relation to the LSRL	Define r^2 and read a computer printout. **Resources** *DTD*, unit 13: "Correlation" *ISDA*, read p. 157	*PS*, chap. 3, nos. 34–37; read sec. 3.3 *SMW*, p. 133, nos. 11, 12; p. 135, no. 23
23	• Finding the SSM and SSE when looking at a linear regression	**Activity** As a group, work through finding the SSM and SSE of four data points. Calculate r^2.	*PS*, chap. 3, nos. 38–41
24	• Influential points and outliers in relation to the LSRL	Review guided notes. Board problems **Resources** *SMW*, read "Butterfly Ballot," pp. 167-68	*PS*, chap. 3, nos. 42, 43, 45 FRQs, 1998 nos. 2 and 4
25	• Residual plots using the graphing calculator • Slope, correlation, and coefficient of determination using correct statistical language	Board problems **Resources** *ISDA*, "Correlation," p. 175, nos. 5.30, 5.31; p. 189, nos. 5.42, 5.43 *SMW*, read pp. 147-52	*PS*, chap. 3, nos. 46–48, 50–52

Day	Topic	Activities and Resources	Homework
26	• Linear regression concepts applied to problems for which students have generated their own data • Reading a computer printout	Board problems Answer questions about the plant project. **Resources** *SMW*, read pp. 152-53 *VS*, chap. 15, p. 287	*PS*, chap. 3, nos. 57, 60, 61 Practice FRQs 1999 no. 1, 2000 no. 1
27	• Review for test 3	Problem no. 65 in class Work in groups at the board to complete review problems.	*PS*, chap. 3, nos. 62, 64, 68, 73 FRQ, 2005 no. 3
28		TEST 3 (chaps. 1, 2, and 3)	*PS*, read sec. 4.1
29	• Exponential and power functions in relation to statistics • Importance of linear relationship in statistics	Sec. 4.1: Transforming Relationships Review log properties.	*PS*, chap. 4, nos. 14–16, 25
30	• Transformations of exponential functions • Transformations in relation to the residual plot	Sec. 4.2: Cautions About Correlations and Regressions Making transformations of exponential functions **Resources** *DTD*, unit 16: "Questions of Causation" *ISDA*, p. 206, no. 5.52; p. 210, no. 5.61 *ABS*, "Matching Graph to Scatterplot," pp. 50–55	*PS*, chap. 4, nos. 33–37
31	• Transformations of power functions and their relation to residual plots	Making transformations of power functions	Complete the plant project. FRQs, 1997 no. 6, 2005B nos. 5A and 5B
32	• Using the graphing calculator to make and interpret residual plots	Residual plots Making residual plots using the calculator	*PS*, chap. 4, nos. 38, 39, 41–43
33	• Confounding and lurking variables • Distribution tables and conditional probabilities • Marginal distributions	Sec. 4.3: Relations to Categorical Data Confounding variables Lurking variables	*PS*, chap. 4, nos. 50–54

Day	Topic	Activities and Resources	Homework
34	• Using distribution tables to determine conditional probabilities • Simpson's Paradox	Conditional distribution Simpson's Paradox	*PS*, chap. 4, nos. 59–62
35		TEST 4 (chaps. 3 and 4)	FRQ, 2004B no. 1
36	• Review: describing data with graphs and numerical values	Review for nine-week exam. Homework test (30 minutes)	
37	• Review: bivariate data	Review chaps. 3 and 4.	
38		Review	
39		NINE-WEEK EXAM	

Quarter 2 (PS Chapters 5–8)

Day	Topic	Activities and Resources	Homework
1	• Parts of a survey • Population of interest • Retrospective and prospective studies	Sec. 5.1: Designing Samples **Activity** Explain the survey project. With a partner, students design two ways to ask the same question to gather information about a particular topic. **Resources** *DTD*, unit 18: "Survey" *DTD*, unit 15: "Designing Experiments" *SMW*, read pp. 6–8, 246-55, and 263, nos. 1–5 *ABS*, "Random Rectangles," pp. 99–102	*PS*, read sec. 5.1; chap. 5, problem nos. 1–6, 10, 11, 13, 15, 16 Complete the survey project. *SMW*, p. 13, nos. 1–14
2	• Sampling techniques	Describe the various types of sampling techniques. **Resources** *SFE*, "Random Sampling," pp. 28, 64; "Experimental Error," p. 24 *SMW*, read pp. 229-34 *ISDA*, p. 27, no. 2.17; p. 55, no. 2.23	*PS*, chap. 5, nos. 21–23, 25, 28

Day	Topic	Activities and Resources	Homework
3	• Random digit table for choosing subjects in an experimental design	Explain how to use the random digit table to choose sample. Scheme, stopping rule, repeat digits **Activity** *PS*, class problem no. 21	*PS*, read sec. 5.2 FRQ, 1999 no. 6
4	• Three principles of experimental design	Principles of experimental design Plant experiment revisited **Resources** *ISDA*, read pp. 29; 37, no. 32	*PS*, chap. 5, nos. 31–33
5	• Randomization in relation to statistical inference • Biased samples	Randomization and why it is important **Resources** *SMW*, p. 243, nos. 4–6, 12, 13	*PS*, chap. 5, nos. 34–36
6	• Diagrams to explain experimental design • Randomization of treatment • Confounding variables • “Blocking”	Principles of experimental design Drawing an experimental design RAT (random allocation of treatment) Confounded variables **Resources** *SFE*, “Blocking,” pp. 102-5 *SMW*, p. 244, nos. 15, 16 *ISDA*, p. 36, no. 28	*PS*, chap. 5, nos. 37–39, 41, 42
7	• Block design and matched pair design	**Activity** Writing the alphabet backward with/without practice **Resources** *SMW*, p. 263, nos. 3, 5	*PS*, chap. 5, nos. 43–46, 50, 51, 53; read sec. 5.3
8	• Using a graphing calculator to simulate experiments when the digits are repeated	Sec. 5.3: Simulating Experiments Chance behavior Assigning digits **Activity** Problem no. 70 (birthday)	*PS*, chap. 5, nos. 56, 58 FRQs, 1997 no. 2, 1998 no. 3

Day	Topic	Activities and Resources	Homework
9	• Experimental design and the plant project	Discuss the plant project and the guidelines for the report.	*PS*, chap. 5, nos. 61–63, 69, 70 FRQ, 2000 no. 5
10	• Comparison of the plant projects—the first one after chapter 3 and this one after chapter 5	Allow students time to work in groups to complete the project and summarize their data. Answer questions and discuss the concepts of lurking and confounded variables.	*PS*, chap. 5, nos. 74–76, 79 FRQs, 2001 no. 4, 2003 no. 4, 2006 no. 5
11		TEST 1 (chap. 5)	*PS*, read sec. 6.1
12	• Law of large numbers • "Random" phenomena as they apply to probability	Sec. 6.1: The Idea of Probability **Activity** Class applies the law of large numbers. **Resources** *ABS*, "The Law of Averages," p. 68	*PS*, read secs. 6.1 and 6.2; chap. 6, nos. 4, 11
13	• Methods to display sample space • Determining the probabilities of each event • Multiplication principle • Disjointed events	Sec. 6.2: Probability Models Tree diagrams Sample space Venn diagrams Complements of events **Activity** *ABS*, "Streaky Behavior: Runs in Binomial Trials," p. 65 **Resources** Problem 6.3, p. 334: class activity	*PS*, chap. 6, nos. 11, 14, 15, 17, 18 FRQ, 1997 no. 3
14	• Web sites related to probability	Computer lab activity with Venn diagrams Basic probability simulations	*PS*, chap. 6, nos. 19–21, 23, 24–26
15	• Independent events in relation to disjointed events	Independence and the multiplication rule FRQ, 1997 no. 3	*PS*, chap. 6, nos. 27–29, 31, 32–35

Day	Topic	Activities and Resources	Homework
16	• Applying probability concepts to application problems • Rule for justifying independence of events	Sec. 6.3: General Probability Rules General addition rule for disjointed and nondisjointed events Rule for independence	*PS*, chap. 6, nos. 37–40, 43, 46, 47; read sec. 6.3 FRQs, 1999 no. 5, 2006 no. 3B
17	• Conditional probability • How to prove events are independent	Conditional probability and how this applies to independence **Resources** *ISDA*, p. 259, no. 6.31	*PS*, chap. 6, nos. 48–50, 52, 53, 56, 57 FRQs, 2002B no. 2, 2003B no. 2
18	• Applying the rules of probability to all types of problems	Review guided notes for chap. 6.	*PS*, chap. 6, nos. 58–64
19	• Gathering data on sensitive issues	**Activity** Problem no. 87 in class **Resources** *ABS*, "Randomized Response Sampling: How to Ask Sensitive Questions," pp. 131-33	*PS*, chap. 6, nos. 67–70, 71, 73
20	• Review for test 2	**Resources** *ISDA*, p. 268, nos. 6.41, 6.42, 6.44	*PS*, chap. 6, nos. 74–77
21	• Review for test 2	Review for test 2. Board problems **Resources** *ISDA*, p. 269, no. 6.47; p. 297, no. 6.91	*PS*, chap. 6, nos. 78–80, 83, 86
22		TEST 2 (chaps. 5 and 6)	
23	• Random variables • Applying probability to random events	Sec. 7.1: Random Variables Define discrete and continuous random variables. **Resources** *SMW*, "Law of Large Numbers," pp. 275-77	*PS*, chap. 7, nos. 2–5

Day	Topic	Activities and Resources	Homework
24	• Normal distribution in relation to a histogram • Applying a probability distribution to a histogram	**Activity** Using dice, create a probability distribution table, and convert this to a histogram. Show how a discrete random variable can approximate a normal distribution. **Resources** *ISDA*, p. 315, nos. 12–14, 19	*PS*, chap. 7, nos. 6, 7, 10, 11
25	• Types of density curves • Density curve for continuous random variables in relation to a probability distribution	Sec. 7.2: Mean and Variance of Random Variables Law of large and small numbers **Activity** The king of large numbers The imaginary queen of small numbers **Resources** *SMW*, read pp. 276-77	*PS*, chap. 7, nos. 14, 16–18, 20
26	• Rules for combining two sets of data • Applying the rule for mean and variance when adding or subtracting means or standard deviations	Sec. 7.2: Combining Normal Random Variables Rules for means and standard deviation when combining random variables $\mu_{x+y} = \mu_x + \mu_y$ $\mu_{x-y} = \mu_x - \mu_y$ $\sigma^2{}_{x+y} = \sigma^2{}_x + \sigma^2{}_y$ $\sigma^2{}_{x-y} = \sigma^2{}_x + \sigma^2{}_y$ $\sigma^2{}_{a+bx} = b^2\sigma^2{}_x$ **Resources** *FF*, demo 22: “How Errors Add,” p. 83 *SMW*, read pp. 313-15; p. 322, nos. 24–28	*PS*, chap. 7, nos. 24–26, 29 *ISDA*, p. 321, no. 7.26 FRQ, 2001 no. 2
27	• Applying the probability distribution and histogram when creating dice	**Activity** Dice activity (review for chap. 7): students create their own set of dice and generate a probability distribution along with a histogram.	*PS*, chap. 7, nos. 34–39, 41

Day	Topic	Activities and Resources	Homework
28	• Applying the rules for adding and subtracting means and variance to two independent distributions • Assumptions for combining two normal variables	Homework test Problem no. 47 in class	*PS*, chap. 7, nos. 42, 44–46, 48 FRQs, 2002 no. 3, 2001 no. 2
29	• Review for test 3	Test review questions on the board	*PS*, chap. 7, nos. 54–57, 60, 61, 67 FRQs, 2005B no. 2, 2006 no. 3A
30		TEST 3 (chaps. 6 and 7)	*PS*, read sec. 8.1
31	• Binomial distribution	Sec. 8.1: Binomial Distributions Properties of a binomial distribution	*PS*, chap. 8, nos. 3–10, 11, 13
32	• Parts of a binomial distribution • Conditions for a binomial	B(n, p) and formula for a binomial distribution Problem no. 36: show students how to read the *Minitab* printout.	*PS*, chap. 8, nos. 19, 20, 26, 27
33	• Mean and standard deviation of a binomial distribution • Normal approximation to binomial distributions	Mean = np Standard deviation $np > 10$ and $n(1-p) > 10$ **Resources** *FF*, demo 13: "Building the Binomial Distribution," p. 56 *FF*, demo 14: "More Binomial," p. 59	*PS*, chap. 8, nos. 28–30, 33, 34
34	• Using the graphing calculator to evaluate binomial distributions	Use working: "at least," "at most," "the majority of" binomialpdf (n, p, k) binomials (n, p, k) 1-binomialcdf (n, p, k)	*PS*, read sec. 8.2
35	• Geometric distribution • Conditions for a geometric	Sec. 8.2: Geometric Distribution $P(x = k) = (1-p)^{(k-1)}p$ **Resources** *ABS*, "Waiting for Reggie," p. 79 *FF*, demo 47: "Wait Time and the Geometric Distribution"	*PS*, chap. 8, nos. 37–39

Day	Topic	Activities and Resources	Homework
36	• Mean for a geometric probability • Using the calculator to find the probability of a geometric probability	Complete guided notes for chap. 8. Find mean of geometric $1/p$.	*PS*, chap. 8, nos. 44–47, 50, 54 FRQ, 2001 no. 3
37	• Review chaps. 1–8	Semester exam review: work on questions from chaps. 7 and 8.	*PS*, chap. 8, nos. 55–57, 59, 60 FRQ, 1998 nos. 6B, C, D, E
38		TEST 4 (chaps. 7 and 8)	Semester review
39	• Exam review: chaps. 5 and 6	NINE-WEEK EXAM	Semester review
40	• Exam review: chaps. 7 and 8		
41		SEMESTER EXAM	

Quarter 3 (PS Chapters 9–12)

Day	Topic	Activities and Resources	Homework
1	• Sampling distributions and sample size • Mean and standard deviation of a sampling distribution	Sec. 9.1: Sampling Distributions **Activity** Students create a sampling distribution of size 2 from a population of 3. **Resources** *DTD*, unit 19: "Sampling Distributions"	FRQ, 1998 no. 1
2	• Sampling distributions that involve proportions	Complete problem no. 7 in class. Display the sampling distribution.	*PS*, read sec. 9.2; also chap. 9, nos. 12–17
3	• Rules for sampling distributions involving proportions	Sec. 9.2: Sampling Proportions **Resources** *FF*, demo 23: "Sampling Distributions and Sample Size," p. 85 *FF*, demo 30: "Where Does That Root $p(1-p)$ Come From?"	*PS*, chap. 9, nos. 25–30
4	• Sampling distributions for problems involving means • Variability of a sampling distribution (decreases as the sample size increases)	Review sec. 9.2. Sec. 9.3: Sample Mean, Sampling Error **Activity** Central limit theorem party (see the Student Activities section)	*PS*, chap. 9, nos. 32–34, 39–41 *ISDA*, p. 410, no. 8.9

Day	Topic	Activities and Resources	Homework
5	• Central limit theorem • Compare the CLT to the law of large numbers	Central limit theorem Do problem no. 44 in class. **Resources** *VS*, "The Central Limit Theorem," p. 127	*PS*, chap. 9, nos. 43, 45–49; complete guided notes for chap. 9
6	• Applying sampling distributions to proportion and mean problems	Review for test 2. Board problems **Activity** Computer lab	*PS*, chap. 9, nos. 50–53 FRQs, 2004B no. 3C and 3D; 2006B no. 3B
7		TEST 1 (chaps. 8 and 9)	*PS*, read sec. 10.1
8	• Inference as a process for drawing conclusions from data • Confidence intervals	Sec. 10.1: Introduction to Inference and Estimating with Confidence CI = $\bar{X} \pm z^* \frac{\sigma}{\sqrt{n}}$ **Resources** *DTD*, unit 20: "Confidence Intervals" *ABS*, "Confidence Intervals," p. 120	*PS*, chap. 10, nos. 1, 2–4
9	• Applying the confidence formula to an application problem	**Activity** Given a situation, have each student find his or her own confidence interval and display this on the overhead (*PS*, p. 541). **Resources** *ABS*, "How Many Tanks?", pp. 148-50 *FF*, demo 32: "How the Width of a Confidence Interval Depends on *N*," p. 110	*PS*, chap. 10, nos. 5–7, 9, 10
10	• Using the graphing calculator to find the appropriate confidence interval • Margin of error for a given confidence interval • Assumptions and conditions necessary for finding a confidence interval	Sample size conditions and assumptions MOE $z^* \frac{\sigma}{\sqrt{n}}$ Finding the z^* Calculator steps **Resources** *FF*, demo 29: "Capturing with Confidence Intervals"	*PS*, chap. 10, nos. 12, 13, 17–20 *ISDA*, p. 467, no. 9.33; p. 453, no. 9.14; p. 454, no. 9.25

Day	Topic	Activities and Resources	Homework
11	• Tests of significance • Null and alternative hypothesis	Sec. 10.2: Test of Significance H_o H_a α level **Resources** *DTD*, unit 21: "Test of Significance"	*PS*, chap. 10, nos. 21–24; read sec. 10.2
12	• Apply the basic part for finding a test of significance	Outline of a test One-sided tests, two-sided tests	*PS*, chap. 10, nos. 27, 29–32
13	• How the conclusion is used in a test of significance • Using the graphing calculator to find the *P*-value in a test of significance	*P*-value and statistical significance Calculator steps	*PS*, chap. 10, nos. 35, 36, 38, 39
14	• Conclusions for confidence intervals and two-sided tests	Confidence intervals and two-sided tests Conclusions	*PS*, chap. 10, nos. 43–46; read sec. 10.3
15	• Using the level of significance to reject the null	Sec. 10.3: Making Sense of Statistical Significance	*PS*, chap. 10, nos. 47, 51–55
16	• Review calculator steps for inference test and confidence intervals for one- and two-sided tests	Calculator steps Homework test	*PS*, chap. 10, nos. 58, 62, 64
17	• Type I and Type II errors • Probability of Type I and Type II errors	Sec. 10.4: Inference as a Decision Type I and Type II errors **Activity** *VS*, "Visualizing Power," p. 209 Type I and Type II errors *ISDA*, p. 487, nos. 10.13, 10.14	*PS*, chap. 10, nos. 67, 68, 79–81
18	• Power of the test in relation to sample size and significance level	Power of the test increase and decrease Sensitivity of the test **Resources** *FF*, demo 44: "Power," p. 144	*PS*, chap. 10, nos. 82, 86–88
19		TEST 2 (chaps. 9 and 10)	*PS*, read sec. 11.1
20	• *t* distributions and tests of significance • Assumptions and conditions necessary for a *t* distribution	Sec. 11.1: Inference for the Mean of a Population *t* distributions Degrees of freedom Problem no. 5 in class **Resources** *VS*, chap. 9, p. 165	*PS*, chap. 11, nos. 2–4, 7–9

Day	Topic	Activities and Resources	Homework
21	• Applying the one-sample *t* test to a matched pair design	Matched pair *t* procedure **Resources** *FF*, demo 38: "Using a *t* Test to Compare Means," p. 129	*PS*, chap. 11, nos. 10, 13, 15
22	• Finding the power of the test using the two-sample *t* test	Power of a *t* test **Resources** *FF*, demo 44: "Power," p. 144	*PS*, chap. 11, nos. 17–19
23	• Applying a test of significance when comparing two means • Assumptions and conditions necessary for comparing two means • Using the graphing calculator to find the *P*-value for a test of significance when comparing two means	Sec. 11.2: Comparing Two Means Conditions and assumptions Conclusions Calculator steps **Resources** *VS*, chap. 10, p. 187 *ISDA*, p. 575, no. 11.55	*PS*, chap. 11, nos. 20, 21, 27, 29; read sec. 11.2 FRQs, 2004 no. 6, 2002 no. 5
24	• Reading a computer printout for a two-sample *t* test • Pooled and unpooled data	Reading computer printouts Pooled and unpooled procedures **Resources** *ISDA*, p. 584, nos. 64, 65	*PS*, chap. 11, nos. 40, 41, 43, 47, 49 FRQs, 1997 no. 5, 2006 no. 4, 2005 no. 6
25	• Applying the principles of a two-sample *t* test and matched pair *t* test using self-generated data	One- and two-sample procedures for test or confidence intervals **Activity** Hula-Hoop® activity for comparing two means	*PS*, chap. 11, nos. 53–55, 59, 67
26	• Applying a *t* test with self-generated data	Complete Hula-Hoop activity and review rubric.	
27		TEST 3 (chaps. 10 and 11)	*PS*, read sec. 12.1
28	• Using statistical inference with categorical data • Standard error of a proportion • Assumptions and conditions for a test of proportion	Chap. 12: Inference for Proportions Sec. 12.1: Inference for a Population Proportion Conditions and assumptions $\sqrt{\frac{p(1-p)}{n}}$	*PS*, chap. 12, nos. 4, 5, 7, 8 FRQs, 1997 no. 4, 1998 no. 5

Day	Topic	Activities and Resources	Homework
29	• Sample size and margin of error for a proportion test • Using the graphing calculator for a proportion test	Sample size and margin of error Calculator steps	*PS*, chap. 12, nos. 10, 12, 15, 16; read sec. 12.2 FRQ, 2006B no. 4
30	• Comparing two proportions when doing a confidence interval • Standard error for a two-sample proportion	Sec. 12.2: Comparing Two Proportions Parts of the test and confidence interval $\sqrt{p_c(1-p_c)\left(\frac{1}{n_1}+\frac{1}{n_2}\right)}$ Pooled and unpooled Standard error	*PS*, chap. 12, nos. 29, 30, 33, 34 FRQs, 2004B nos. 3 and 6A
31	• Using the calculator for one- and two-proportion tests and for confidence intervals	Calculator steps	*PS*, chap. 12, nos. 35, 37–39
32	• Review chaps. 11 and 12	Review for test 4	
33		TEST 4 (chaps. 11 and 12)	*PS*, read sec. 13.1
34	• Review chaps. 9–12	FRQs, 1999 no. 2, 2002 no. 6	FRQs, 2005B nos. 4 and 6A
35	• Review chaps. 9–12	FRQ, 2004 no. 5A	
36		NINE-WEEK EXAM	

Quarter 4 (PS Chapters 13–14, Review, and Final Project)

Day	Topic	Activities and Resources	Homework
1	• Chi-square test for goodness of fit and when it is appropriate	Sec. 13.1: Test for Goodness of Fit **Activity** M&M's activity Part of the chi-square test	*PS*, chap. 13, nos. 4, 5, 7 FRQs, 2003 nos. 2 and 6; review problems
2	• Assumptions and conditions necessary for a chi-square test • Determining the expected counts and the chi-square value	Assumptions and conditions for chi-square test Expected counts Observed counts **Resources** *VS*, chap. 13: "Goodness of Fit," p. 249	*PS*, chap. 13, nos. 10, 11, 13
3	• Appling the chi-square test for independence and test for homogeneity	Sec. 13.2: Inference for Two-Way Tables Chi-square test for independence and homogeneity Conclusions for chi-square tests **Resources** *SMW*, read pp. 518-31 and p. 537, nos. 1–4	*PS*, chap. 13, nos. 15, 18, 21, 29

Day	Topic	Activities and Resources	Homework
4	• Reading a computer printout for chi-square and linear regression • Assumptions and conditions for chi-square	Assumptions and conditions for chi-square independence test Calculator steps Computer printout, pp. 787, 793 **Resources** *ABS*, "Is Your Class Differently Aged?" (chi-square test), p. 163	FRQ, 2003 no. 5
5		TEST 1 (chaps. 12 and 13)	*PS*, read sec. 14.1; chap. 14, nos. 2, 3
6	• Null and alternative hypothesis for inference for regression • Standard error for the slope • Reading a computer printout for a linear regression test	Sec. 14.1: Inference About the Model, Null, and Alternative Standard error for the slope Residuals and standard error Degrees of freedom	*PS*, chap. 14, nos. 6, 11, 12
7	• Assumptions and conditions for a linear regression test	Sec. 14.2: Predictions and Conditions **Resources** *SFE*, "Residual Checking," pp. 183-84	*PS*, chap. 14, nos. 13–15 FRQs, 2005B no. 5C, 2001 no. 6B, 2006 no. 2C
8		TEST 2 (chaps. 13 and 14)	
9	• Review: multiple-choice questions	Practice AP multiple-choice problems (*APS*)	*APS*, model exam 1, p. 264
10	• Review: multiple-choice questions	Practice AP multiple-choice problems (*APS*)	*APS*, model exam 2, p. 274
11	• Review: multiple-choice questions	Practice AP multiple-choice problems (*APS*)	*APS*, model exam 3, p. 284
12	• Necessary steps for inference for the spread of a population • Applying the *F* test to inference • Reading a computer printout comparing two standard deviations	Sec. 15.1: Inference for Population Spread *F* test comparing two standard deviations	Practice FRQs, 2005 no. 6, 2006 no. 6
13	• Review: describing data	Review for AP Exam, chaps. 1–4	Multiple-choice questions from the *AP Statistics Course Description*
14	• Review: experimental design	Review for AP Exam, chap. 5	
15	• Review: probability	Review chap. 6	
16	• Review: inference	Review chaps. 7 and 8	
17	• Review all topics	Review chaps. 9–12	

Day	Topic	Activities and Resources	Homework
18		**AP EXAM**	
19	• Binary predictors in regression	**Resources** *VS*, chap. 19: "Binary Predictors in Regression"	
20	• Trimmed mean	**Resources** *ISDA*, "Trimmed Mean," p. 109	
21	• Spearman rank	**Resources** *ISDA*, "Spearman Rank," p. 161	
22	• Hypogeometric distribution	**Resources** *FF*, demo 49: "Sampling Without Replacement and the Hypergeometric Distribution"	

Teaching Strategies

I have often found that those students who receive a grade of 2 on the AP Exam have worked the hardest and have shown the most growth. It is important to keep these students motivated to continue their education. Sometimes they will not apply to college because they do not see themselves as successful, and academic achievement is not promoted at home. This course is their first attempt and can set the stage for college and further education. Keeping these students successful and motivated is one of the most difficult tasks in teaching AP Statistics. Setting up an environment where they can ask questions and not be intimidated by the more advanced students has been a challenge. I often seat these students in the front, where I can see if their facial expressions indicate that they do not understand. The more advanced students are on the sides of the room, where I can make sure they are on task, or in the back, where sometimes I give them more challenging problems to work through individually.

A motivating factor for every student is the "brag wall" above the blackboard in my classroom, where I post the names of all the students who have achieved a grade of 3 or higher on the AP Exam since 1999. The names of the students who have received a 5 are larger and in bold letters. This is a strong incentive for those high-level students who define success as earning a 5. The lower-level students are ecstatic to see their names posted at all.

I weave a variety of activities into the class, each of which can be adjusted according to the needs of my students. They range from short activities that engage students as they enter the classroom to larger projects that are assessed at the end of the semester. For more examples, see the Student Activities section at the end of this syllabus.

Data-Gathering Activities

Most students understand abstract concepts better when they see the connection with something they have experienced. I often have students collect data about themselves or the school—for example, how many numbers do you and/or your parents have stored in your cell phone? What is the average tip you leave in restaurants? How many hours do you spend reading e-mail? How many students do not have parking stickers? How long do you spend waiting in line in the cafeteria? Students enjoy collecting information that relates directly to themselves, and we discuss how data are often used to make decisions or persuade people to think in a certain manner. The data are displayed in hand-drawn graphs, and students are required to explain and interpret the distributions in written assignments. This is followed by a short demonstration to the class. After drawing graphs by hand, students use the calculator to produce the same type of display.

Through exploration they find the window adjustments and scales necessary to create a useful graphical representation. I find the kinesthetic learner benefits the most from these strategies, and all students start to see the usefulness of statistics from the very beginning of the year.

Exploration Activities

Students often use the calculator to explore concepts by using simulation and trial-and-error methods. For example, they are given five data points and are directed to come up with various means and standard deviations by manipulating them. An example of the trial-and-error method is shown below.

Students are given a number line from 0 to 20 and are presented with the following task:

- Place the dots 2, 7, 10, 13, and 18, and estimate the mean and standard deviation. Check your estimate using your calculator.
- Change the data in the previous item so that the mean is the same but the standard deviation is about 3.
- Place the five numbers so that the mean is 15 and the standard deviation is about 3.
- Place four numbers so that the mean is 5, and add 3 to each number. What is the effect on the mean and standard deviation?
- Arrange five numbers so that the standard deviation is larger than the mean.

Jeopardy!

The objective is to review previously learned material and integrate it into the new concepts. We have a variety of *Jeopardy!*-type games, presented in *PowerPoint*, that we often play for a few minutes at the end of class. The questions are fairly simple—generally fill-in-the-blank or multiple-choice problems. The problems for the game were developed by students from earlier years, and the game parallels *Jeopardy!* in that the questions are categorized by the chapters in the textbook or by topic. Example: *What is the rule for justifying an outlier?*

Physical Movement

I have created a series of physical movements that are linked to various concepts in order to help the kinesthetic learner. For example, the four conditions of a binomial distribution are each represented by a unique physical movement. When students enter the classroom, they may be asked to indicate the four conditions for a binomial distribution by using these physical movements. (Fixed number of outcomes: stand up straight; two outcomes: hold out the left and right hands; probability remains the same: turn right and left to show that both sides of one's face are the same; independence: kick with one foot to show that it is independent of the other foot.) When students come back the next year, they still remember the movements and the four conditions for binomial distributions.

Guided Notes

Guided notes are used with each chapter to help the low-level reader better understand the material presented. These notes help students to clarify the important parts of the chapter and to see what concepts they should have gathered from the reading. Examples can be found at the Mrs. Krummel Web site listed in my Teacher Resources section.

Acronyms and Audiovisual Aids

Students in the past have developed their own acronyms and musical tunes to aid in the memorization of concepts, and this helps them recall some of the basic principles involved in the course. I continually emphasize the need to be able to communicate these concepts and use the memorization device to begin that process. A visual display of two rats in a box helps students recall the three principles of experimental design: random allocation of treatment (RAT); replication (indicated by *two* rats); and control of the process (represented by the box). I place two plastic rats in a box as the students enter the classroom. When the bell rings, they have four minutes to explain the three principles of experimental design. For homework they begin the design of a simple experiment incorporating these principles.

Computer Lab Activities

The students go to the computer lab at least once each quarter. During this structured class, they investigate various Web sites that contain applets, online demonstrations, and simulations in order to tackle some of the harder concepts. I give them a handout that lists about seven Web sites and asks specific questions that they must answer as they explore each one. This guides the students through the discovery process, keeps them on task, and gives me the opportunity to walk around and help the weaker members of the class. Some students do not have access to computers at home and need class time and technical support to work through these activities. Although each student has his or her own computer station in the lab, I assign the students in pairs based on their technical and mathematical ability.

Scoring AP Exam Responses

During the second semester, students are assigned individual AP Exam free-response questions in class and as part of some homework assignments. The following day, the class is organized in the style of an AP Reading, and each student is assigned a partner. The partners for this venture are picked carefully. A strong mathematical student but poor writer is often paired with a student who is weak in mathematics but strong in written communication. Each pair has to assess about six responses to the same problem. The scoring guidelines are explained, and they then score their assigned free-response papers and sign their names at the bottom. Each class reads a different question, and the papers are returned the next day. This activity gives students a better understanding of the level of work expected on the AP Exam. It also helps them focus on the importance of communicating their results rather than just writing down a numerical answer.

The free-response questions from all prior AP Exams are kept in a set of binders for easy access at any time. Often when a class discussion arises, it turns out that a previous question has specifically addressed that concept. Having the questions readily available saves time and makes the learning process flow more easily.

Review for the AP Exam

The review process starts with a mock AP Exam about one month before the real exam. The event, running from 9 a.m. to noon on a Saturday, is hosted by one of four participating high schools and usually attracts about 300 students. We give the free-response section first, have refreshments, and follow with the multiple-choice questions. This allows us to begin scoring the free-response questions immediately. The statistics teachers finish marking the exams that afternoon, so they can be returned to the students promptly. Using the sheet from the 2002 Released Exam that shows what factor each question's score was multiplied by, students can determine if they would have gotten a grade of 1, 2, 3, 4, or 5 on the mock exam. I realize that the conversion changes every year as the questions change, but it gives students an idea of how the scoring and grading work. They can then go over their work in their home schools. Students who do well on the mock test can count it as their fourth-quarter exam. Those who do poorly are allowed to count it as a 100 percent grade on one of their tests (regardless of the grade they actually received), which is then averaged in with their other test grades. The replacement option for the fourth-quarter exam motivates the stronger students, and the extra-credit points encourage the weaker ones to take the mock exam. If they are not able to attend on Saturday, they must stay after school two days before the scheduled event to take the exam and receive the same incentives.

In addition to the mock exam, we have two major review sessions with the other schools in the county. These are held on Saturday mornings. Each teacher presents one of the four major topics of the course, with students rotating around the classrooms and hearing the topics presented. For each hour that students attend, they receive three points extra credit that may be used on any test during the fourth quarter.

There are also individual review sessions at each school. At Seminole High School, these take place after school from 4–6 p.m. or 5–7 p.m. Each session is worth extra-credit points if attended. We review the material using a short *PowerPoint* presentation, followed by a group activity that applies these concepts. Because our class periods are only 49 minutes, these two-hour blocks present a unique opportunity to further review what students should have learned in class. Refreshments are provided. Former students have said that these review sessions, presented during the two weeks before the exam, were most beneficial to them.

After the AP Exam

Over the years I have introduced a variety of projects and/or new topics after the AP Exam. In the past, our students started school on July 31, and the term ended around May 18, so there were not too many days left at the end of the year. We are now starting school on August 20 and do not end until June 10, so I will be incorporating these same ideas, but with more detail. Some of the past activities are listed below.

- I have a mathematical library in my classroom. These titles are not textbooks but popular nonfiction that explores mathematics at the secondary level. The books have been collected over the years, with some purchased from retired math teachers. Students pick a book to read, write a report about it, and then design an activity from the book and present it to the class. The report must include a summary of the book and suggest how other mathematics classes could incorporate it in their curricula. This was one of the most well-received activities—students enjoyed seeing mathematics presented in a new light. Here are some of the titles in this library:

Title	Author
Alice in Quantumland	Robert Gilmore
Another Fine Math You've Got Me Into . . .	Ian Stewart
Archimedes' Revenge	Paul Hoffman
The Art of Mathematics	Jerry P. King
Beyond Numeracy: Ruminations of a Numbers Man	John Allen Paulos
Bridges to Infinity	Michael Guillen
A Brief History of Time	Stephen Hawking
Connections: The Geometric Bridge Between Art and Science	Jay Kappraff
Dead Reckoning: Calculating Without Instruments	Ronald W. Doerfler
Descartes' Dream	Philip J. Davis and Reuben Hersh
Does God Play Dice?	Ian Stewart
The Emperor's New Mind	Roger Penrose

Title	Author
The Enjoyment of Mathematics	Hans Rademacher and Otto Toeplitz
Experiments in Topology	Stephen Barr
Fearful Symmetry: Is God a Geometer?	Ian Stewart and Martin Golubitsky
The Fourth Dimension	Rudy Rucker
From Zero to Infinity	Constance Reid
Fuzzy Logic	Daniel McNeill and Paul Freiberger
Game, Set, and Math	Ian Stewart
Gödel, Escher, Bach: An Eternal Golden Braid	Douglas R. Hofstadter
How to Solve Problems	Wayne A. Wickelgren
Innumeracy: Mathematical Illiteracy and Its Consequences	John Allen Paulos
Islands of Truth	Ivars Peterson
Mathemagics: How to Look Like a Genius Without Really Trying	Arthur Benjamin and Michael Brant Shermer
The Mathematical Experience	Philip J. Davis and Reuben Hersh
Mathematical Thought from Ancient to Modern Times (three volumes)	Morris Kline
The Mathematical Tourist	Ivars Peterson
The Mathematical Universe	William Dunham
A Mathematician Reads the Newspaper	John Allen Paulos
A Mathematician's Apology	G. H. Hardy
Mathematics and the Search for Knowledge	Morris Kline
Mathematics for Everyman	Laurie Buxton
Mathematics for the Million	Lancelot Hogben
Mathematics in Art	Michael Holt
Mathematics in Western Culture	Morris Kline
Mathematics: People, Problems, Results (two volumes)	Douglas M. Campbell and John C. Higgins, eds.
Mathematics: The Loss of Certainty	Morris Kline
Mathsemantics: Making Numbers Talk Sense	Edward MacNeal
Mazes for the Mind	Clifford A. Pickover
Metamagical Themas	Douglas R. Hofstadter
Mind Tools: The Five Levels of Mathematical Reality	Rudy Rucker
The Most Beautiful Mathematical Formulas	Lionel Salem, Frédéric Testard, and Coralie Salem
The Nature and Growth of Modern Mathematics	Edna E. Kramer
Nature's Numbers: The Unreal Reality of Mathematical Imagination	Ian Stewart
Number	John McLeish
100 Great Problems of Elementary Mathematics	Heinrich Dörrie
On the Shoulders of Giants	Lynn Arthur Steen, ed.

Title	Author
Paradigms Lost	John L. Casti
The Paradoxicon	Nicholas Falletta
The Penguin Dictionary of Curious and Interesting Geometry	David Wells
Pi in the Sky: Counting, Thinking, and Being	John D. Barrow
Practical Reasoning	Larry Wright
Prisoner's Dilemma	William Poundstone
The Problems of Mathematics	Ian Stewart
Readings in Mathematics, book 2	Irving Adler, ed.
Thinking Machines	Irving Adler
The Tinkertoy Computer	A. K. Dewdney

- Students have designed *Jeopardy!*-type games (described earlier in this section) and multiple-choice questions to be used in the following year. They have also done *PowerPoint* presentations showing how statistics is involved in the recycling process throughout the country. This project includes making blankets for the homeless out of recycled plastic grocery bags. Although the Web site is under construction, a picture of the weaving process for these blankets can be found at http://home.cfl.rr.com/swaynos.
- I have explained how probability is involved in gambling, such as card games that are played on the Internet.
- I have discussed different types of mortgages and how interest is determined using credit cards. The class has done exploratory activities using the financial applications on the TI-83.
- I have continued teaching analysis of variance.

Student Evaluation

Students receive one grade for each semester. Each nine-week quarterly grade is worth 40 percent, and the semester exam counts for 20 percent.

The students' quarterly grades are determined as follows:

Tests	45 percent
Homework	20 percent
Participation and quizzes	20 percent
Nine-week exam	15 percent

The school's grading scale is standard:

A = 90–100 percent
B = 80–89 percent
C = 70–79 percent
D = 60–69 percent
F = Below 60 percent

Tests

Approximately five tests are given during each nine-week period. They generally are spiral tests, which means that they include previously learned concepts. One of them is a take-home test, on which students may work together. Another is taken directly from the homework problems, which encourages students to complete the homework and learn the concepts. These two assessments help weaker students to succeed in the class.

For the other three tests, I put a review sheet online a few days before the test, and students can see me before or after school to ask questions about it. I collect these sheets at the start of the test, and if the work has been done satisfactorily, the student may earn up to an additional 10 points on the test. Students who understand the review sheet are likely to do well on the free-response questions on the test itself.

All the exams are half multiple-choice and half free-response questions and are designed to occupy a 45-minute class period. Students may use calculators and formula sheets at all times.

Homework

Homework takes approximately 30–45 minutes a night. It is collected daily and graded on completeness. The classroom is open every morning at 6:15 so that students can work together to finish their homework. I am available to tutor and administer makeup tests and quizzes at that time. Students may also make appointments after school if they are behind in class or need more individual instruction.

At the start of class I put a problem on the overhead and walk around to assess the students' homework. If they made an attempt at every problem, then they generally get full credit for the homework. No late work is accepted, and if students are sick, they have one day to make up the work for each day of absence.

Participation

Students go to the board and complete problems at least twice a week, receiving a participation grade for this work. They have indicated that this is the most successful way of learning to solve problems, and they enjoy this part of the class. I pair weak and strong students. The less-able students then see that the stronger ones often do not fully understand the concept either, and this can make them less inhibited about asking questions. If you do not have enough board space, try small 2 by 3 foot whiteboards that the students can use at their seats. I can quickly grade the board work, especially the communication part of the problem. Students listen as I grade their classmates' problems and make changes before I get to their work. Sometimes the more advanced students have poor communication skills but understand the mathematics. The weaker students may know all the details but often miss important mathematical procedures. Together they often make a good team and learn from each other.

Students who are absent must take a makeup quiz the next morning to replace this participation grade. Attendance has occasionally been a problem in the past, and this practice has effectively reduced unexcused absences.

Students are sometimes given three or four multiple-choice questions at the start of class and may work together on the answers as a participation grade. The questions come from the previous night's reading homework. They are posted at the start of class, and students have only a few minutes to work on the problems. This encourages them to get to class on time and begin working immediately. It also gives them more practice with multiple-choice questions.

Nine-Week Exam

This is given during one 49-minute class period at the end of each nine weeks. It is 75 percent multiple-choice and 25 percent free-response questions.

Teacher Resources

Primary Text

Yates, Daniel S., David S. Moore, and George S. McCabe. *The Practice of Statistics: TI-83 Graphing Calculator Enhanced*. 2nd ed. New York: W. H. Freeman, 2003.

Supplementary Books

Bock, David E., Paul F. Velleman, and Richard D. De Veaux. *Stats: Modeling the World*. Boston: Pearson/Addison-Wesley, 2004.

Bohan, James. *AP Statistics: Preparing for the Advanced Placement Examination*. New York: AMSCO, 2000.

Box, George E., William G. Hunter, and J. Stuart Hunter. *Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building*. New York: Wiley, 1978.

College Board. 1997 *AP Statistics Released Exam*. New York: College Board, 1997.

College Board. 2002 *AP Statistics Released Exam*. New York: College Board, 2002. (Note: The 2007 Released Exam has become available since this syllabus was submitted.)

Doane, David P., Kieran Mathieson, and Ronald L. Tracy. *Visual Statistics 2.0*. Boston: McGraw-Hill/Irwin, 2001.

Erickson, Tim. *Fifty Fathoms: Statistics Demonstrations for Deeper Understanding*. Oakland, Calif.: EEPS Media, 2002.

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. Pacific Grove, Calif.: Brooks/Cole, 2001.

Scheaffer, Richard L., Mrudulla Gnanadesikan, Ann Watkins, and Jeffrey A. Witmer. *Activity-Based Statistics: Instructor Resources*. New York: Springer, 1996.

Technology

Fathom Dynamic Data Software. Version 2. Emeryville, Calif.: Key Curriculum Press. This is used as a teaching demonstration, and once every nine weeks the students have computer access.

Texas Instruments. TI-83 Plus/TI-84 graphing calculators. http://education.ti.com/educationportal/sites/US/homePage/index.html.

Video

Statistics: Decisions Through Data. Written by David S. Moore. Lexington, Mass.: Consortium for Mathematics and Its Applications (COMAP), 1992. Five videocassettes with user's guide (total of 21 video segments).

Web Sites (General)

The following represent the main Web resources used in the course. Some offer online demonstrations using Java applets that help to illustrate many of the key statistical concepts taught.

AP Central. AP Statistics Course Home Page.
apcentral.collegeboard.com/stats.
An essential resource for all AP teachers. From here you can navigate to the free-response questions from previous AP exams.

Coons, Al. BB&N AP Statistics.
www.bbn-school.org/us/math/ap_stats.
Teacher's site with tests, notes, and links to other sites.

Derksen, Jared. The AP Stats Top 10 FAQs.
www.mrderksen.com/top10.htm.

Fr. Chris' AP Statistics.
www.fortunecity.com/campus/anlaby/36.
Teacher site with many resources.

Intuitor.com. Amazing Applications of Probability and Statistics.
http://intuitor.com/statistics/index.html.

Lock, Robin H., Mathematics Department, St. Lawrence University. A Sampler of WWW Resources for Teaching Statistics.
http://it.stlawu.edu/~rlock/maa51/www.html.

Math Forum@Drexel. AP Statistics Electronic Discussion Group Archives.
http://mathforum.org/kb/forum.jspa?forumID=67

Minitab for AP Students.
www.Minitab.com/education/apstatisticshighschool.aspx.

Mrs. Krummel Web site. Teacher site.
http://mrskrummel.com/statteacher.htm.
Guided notes for each chapter of *The Practice of Statistics* can be found at this site, under "YMM Chapter Outlines," as well as many other resources. There is a semester exam review with 200 problems and answers. Guided notes and the answer key are available for purchase, but the exam review can be downloaded for free.

Mrs. Smart's AP Statistics Page. Teacher site.
www.lhs.logan.k12.ut.us/~jsmart/stats.html.

Rice Virtual Lab in Statistics.
http://onlinestatbook.com/rvls.html.

Rice Virtual Lab Simulations/Demonstrations.
http://www.ruf.rice.edu/~lane/stat_sim/.
This portion of the RVLS site has applets that allow students to interact. You can assign activities at home, if students have computer access.

Schott, Brian, Georgia State University. Practice Multiple-Choice Questions for Business Statistics.
www2.gsu.edu/~dscbms/ibs/qcontent.html.

Shodor Education Foundation. Interactivate Activities.
www.shodor.org/interactivate/activities.

W. H. Freeman Co. *The Practice of Statistics*. 2nd ed. Companion site to the textbook.
http://bcs.whfreeman.com/yates2e.

Web Sites (for Individual Chapters in *The Practice of Statistics*)

Chapter 2 (The Normal Distributions)

Flanagan-Hyde, Peter. "Is It Normal?" See link under *Teaching Resource Materials, Anticipating Patterns* on the Statistics Course Home Page on AP Central.

Chapter 3 (Examining Relationships)

University of Illinois at Urbana–Champaign, Department of Statistics. Guess the Regression.
www.stat.uiuc.edu/courses/stat100//java/GCApplet/GCAppletFrame.html.

West, R. Webster, University of South Carolina, Department of Statistics. Regression Applet.
www.stat.sc.edu/~west/javahtml/Regression.html.
Students may add points and investigate how the regression changes.

Chapter 4 (More on Two-Variable Data)

Dallal, Gerard E., Tufts University. The Normal Distribution. Article about the purpose of transformations.
www.tufts.edu/~gdallal/normal.htm.

Chapter 5 (Producing Data)

Dallal, Gerard E., Tufts University. Random Samples/Randomization.
www.tufts.edu/~gdallal/rand.htm.

Derksen, Jared. Exploration: Cheerios. Activity with worksheet.
www.mrderksen.com/Downloads/cheerios.pdf.

NCSSM Statistics Leadership Institute. An Exercise in Sampling: Rolling Down the River.
http://courses.ncssm.edu/math/Stat_inst01/PDFS/river.pdf.
This worksheet explains the difference between SRS and a stratified sample and when it is appropriate to use each.

NCSSM Statistics Leadership Institute. The Helicopter Project: A Factorial Design.
http://courses.ncssm.edu/math/Stat_Inst/PDFS/FacDesgn.pdf.

Schwarz, Carl James, Simon Fraser University. Producing Data.
www.stat.sfu.ca/~cschwarz/Stat-301/Handouts/node54.html.
This site gives definitions of experimental design terms.

Chapter 6 (Probability)

Boggs, Rex. The Game of Greed.
www.lhs.logan.k12.ut.us/~jsmart/greed.htm.
I use this to introduce simulations.

Dallal, Gerard E., Tufts University. Probability Theory.
www.tufts.edu/~gdallal/prob.htm.
Article about a probability density curve and cumulative density curve.

Chapter 8 (The Binomial and Geometric Distributions)

Exner, Nicholas, University of Illinois at Urbana–Champaign, Department of Statistics. Animal Cards.
www.mste.uiuc.edu/reese/cereal/maincereal.html.
This site shows a geometric distribution.

Chapter 9 (Sampling Distributions)

Rice Virtual Lab in Statistics. Simulations/Demonstrations.
www.ruf.rice.edu/~lane/stat_sim/.
This applet displays the central limit theorem. Choose the "sampling distribution" activity.

Chapter 10 (Introduction to Inference)

Bock, David. "Is That an Assumption or a Condition?"
See link under *Teaching Resource Materials, Statistical Interference* on the Statistics Course Home Page on AP Central.

Dallal, Gerard E., Tufts University. Confidence Intervals.
www.tufts.edu/~gdallal/ci.htm.

Hayden, Robert W. "10% Assumption for Inference."
See link under *Teaching Resource Materials, Statistical Interference* on the Statistics Course Home Page on AP Central.

Chapter 11 (Inference for Distributions)

Bullard, Floyd. "On Power."
See link under *Teaching Resource Materials, Statistical Interference* on the Statistics Course Home Page on AP Central.

Chapter 12 (Inference for Proportions)

Peltier, Charles. "Why Do We Pool for the Two-Proportion *z*-Test?"
See link under *Teaching Resource Materials, Statistical Interference* on the Statistics Course Home Page on AP Central.

Student Activities

Foldables

Foldables are three-dimensional, interactive, graphic organizers that students make themselves and use to learn and review critical concepts and vocabulary terms. They are fashioned by folding and cutting paper, and they often have flaps that can be lifted to reveal information. Patterns for creating them are available in various styles and designs that students can adapt to any subject. Below are several URLs for Web sites with examples of foldables used in history or science classes. This same concept can easily be adapted for statistics. Making foldables gives students a visual tool to store, organize, and recall a large quantity of information.

- www.eemes.ccs.k12.nc.us/candler/PDF/foldables.pdf
- www.dinah.com/egroup/Archives.htm

- http://ushistory.pwnet.org/resources/pdf/Geography_Foldables_Photo.pdf
- www.ehhs.cmich.edu/~dnewby/DinahZikefoldables.doc

My students create graphic organizers at the end of each chapter of the textbook, defining each concept and presenting a problem that incorporates that concept. The vocabulary words that were introduced in the chapter are also included. If the foldable is graded as part of a test, it is usually worth about 10 percent. If I know the test is difficult, I use the foldable as 10 points extra credit. At the end of the quarter, I may assign a "take-home" test, asking students to design a foldable that could be used on their nine-week exam. Creative students often excel in this activity, whereas the stronger mathematical students sometimes have difficulty with neatness and the imaginative aspects of the task. We begin this project during a short class period, and I make sure that paper, glue, scissors, and decorative markers are available. At the beginning of the year, I display several examples from past classes, talk about the benefits of completing an organizer, and demonstrate how to use it to study. The scoring guidelines are also explained. Below is a modified rubric that I have used in the past.

- **Mathematical thoroughness** **45 points**
  (Have you included all the necessary concepts with examples for each?
  Are the vocabulary words clearly defined?)
- **Creativity** **25 points**
  (Have you used your personality and creative imagination in the design?)
- **On time** **10 points**
  (Due [date here], before you take your exam)
- **Neatness** **10 points**
  (Is it clearly written and nicely displayed?)
- **Durability** **10 points**
  (Can you continue to use it for the remainder of the year?)

Linear Regression Activity

At the end of chapter 4, when the students have completed linear regression, they engage in an activity that requires them to collect bivariate data and display it using a trifolded 11 by 13 inch piece of construction paper. They start with a question of interest and a fact that will later be defined as a hypothesis. Some examples include the following:

- How are the hours you spend doing homework related to the number of hours you spend reading e-mail?
- How is the percentage of the tip you leave at a restaurant related to the price of your meal?
- How is the simulated probability from playing poker related to the theoretical probability?
- How is the amount of coffee you drink related to the amount of water you drink?
- How is your arm span related to your height?

Students usually become genuinely excited about this kind of assignment if they are addressing a question that interests them rather than being delegated a predetermined task. They collect bivariate data, indicating both the independent and dependent variable and what units were used. They create boxplots and histograms for the univariate data and scatterplots, with a residual plot, for the bivariate data.

The assignment also requires defining the slope, correlation, and coefficient of determination in the context of their data. Students experience the problems that come with actually collecting their own data. They see that zeros often are problems or that a large number of outliers may require adjustments to the data.

Students are then expected to connect the information in their display to their question of interest in a short presentation to the class (four minutes). They should be able to explain and interpret all numerical output and to make a reasonable prediction for some input value that will be asked for during the presentation. The small display boards that I use for this exercise are easy to store and can be brought out in future years as examples. In many ways, this activity mimics a miniature science-fair project.

This small project is counted as a test grade, and the evaluation of each board follows this general format: on time (5); neatness (10); creativity (15); mathematical concepts (20); graphs (20); organization, grammar, and spelling (10); use of technology (5); and presentation to the class (15).

Central Limit Party

We have a "central limit party," where each group of four students receives a different distribution (skewed, uniform, bimodal, normal). Each group takes a sampling distribution of size 5 and size 10 for each distribution. They gather 50 samples for each size. These are drawn as graphs on large sheets of paper. Each distribution is a different color. Each group then calculates the mean and standard deviation for the population and each sample. This is presented to the class, and a picture of each group is taken. Students discover that the mean of their sample is approximately equal to the mean of the population and that the standard deviation is the standard deviation of the population divided by the square root of 5 or 10, respectively.

Students see that all the distributions will approach a normal distribution, but it happens faster when the sample size is larger. This helps the kinesthetic learner as we continually refer back to the graphs and their pictures.

Plant Project

When linear regression is first introduced, each student is given two paper cups filled with potting soil and four bean seeds. (Purchase seeds that germinate quickly so data can be collected within two weeks' time. Usually only one or two actually germinate and grow. If more than one seed per cup germinates, the student keeps only the one that looks the strongest.) They are instructed to fertilize one cup daily with Miracle-Gro® and the other daily with "worm tea," a natural fertilizer that comes from the castings of worms. They measure the height of their plants for 10 days, and then we do a linear regression with x equaling the total amount of fertilizer and y the height of the plant. The students do not follow any structured rules of experimental design. They complete a worksheet after the chapter 3 review of the concepts of linear regression.

When we study experimental design in chapter 5, the same experiment is done again, this time following the correct procedures for randomization of treatment and placement of the plants. We use the first experiment as the foundation to talk about lurking and confounded variables and also how we could incorporate blocking into our design. One student is assigned to do all the watering of both groups of plants.

Hula-Hoop Activity

When testing the difference between two means, students form groups, and we gather data on how many rotations males and females can complete when spinning a plastic Hula-Hoop around their waists. We also do a matched pair design for revolving the hoop clockwise versus counterclockwise. We use one period to collect the data, and the next day the data are analyzed. This activity gives the more coordinated students an opportunity to excel.

UNO® Cards

Often in high school a substantial number of students are pulled out of class for assemblies, senior lunch, pep rallies, field trips, band trips, photos, PSAT/NMSQT or state testing, and so on. This makes teaching new material—or even reviewing old material—difficult. When more than one-third of my class is removed for some such event, I use this activity with the students who are left: I write an easy review question on each card in an UNO deck. As they play the game, students must answer the question before using the card. After the AP Exam, students can create their own decks of cards for next year's students.

Sample Syllabus 8

Josh Tabor
Glen A. Wilson High School
Hacienda Heights, California

School Profile

Location and Environment: Hacienda Heights is an unincorporated, largely residential area, about 20 miles east of downtown Los Angeles. Its best-known landmark is the Hsi Lai Temple, one of the largest Buddhist temples in the Western Hemisphere, whose architecture mimics that of ancient Chinese monasteries. A significant proportion of students at Glen A. Wilson High come from homes where English is not the primary language. The school offers AP courses in 17 subjects; 754 AP Exams were taken in 2007, with 68 percent of the students receiving grades of 3 or better.

Grades: 9–12

Type: Public high school

Total Enrollment: Approximately 1,800

Ethnic Diversity: In 2006-07, the student population was approximately 44 percent Hispanic/Latino and 43 percent Asian American.

College Record: Approximately 54 percent of graduating seniors go to four-year colleges, and an additional 39 percent go to two-year colleges.

Personal Philosophy

Teaching AP Statistics has been the most rewarding and enjoyable experience I have had as an educator. It has been a great opportunity to work with college-bound students, giving them a challenging college-level course that will prepare them for study in almost any field. Numerous alumni have returned to tell me how valuable AP Statistics was and how well-prepared they felt for college.

Class Profile

At Glen A. Wilson High School we offer between two and four sections of AP Statistics each year, with an average class size of about 32. I am the only statistics teacher. The prerequisite for the course is a passing grade in Algebra 2, although many students complete Precalculus first. Concurrent enrollment in Precalculus or AP Calculus is allowed. We are on a traditional daily schedule with 55-minute periods. The school year usually begins after Labor Day and ends in mid-June. It consists of two semesters, with progress reports mailed to the students' homes every six weeks. The relatively late start proves to be a challenge each year, but I manage to finish the curriculum by the early May AP Exam date and use the time after the exam to explore additional topics, such as multiple regression and ANOVA.

Students are encouraged to take the AP Exam, but it is not a class requirement. Typically, at least 80 percent of my students choose to take the exam.

There is no regularly scheduled laboratory for the course; students go to the computer lab only once during the year, although they are given several assignments to do at home on a computer (or in the computer lab on their own time).

Course Overview

The primary text used in this class is the first edition of *Introduction to Statistics and Data Analysis* by Roxy Peck, Chris Olsen, and Jay Devore. (See full citation in the Teacher Resources section later in this syllabus.) I begin the course with the second section of the Topic Outline in the *AP Statistics Course Description*, "Sampling and Experimentation: Planning and conducting a study." This is the first major topic in our textbook and seems a natural place to start, as planning a study is the first step in the statistical process. We then move to the outline's first topic, "Exploring Data: Describing patterns and departures from patterns"; the third, "Anticipating Patterns: Exploring random phenomena using probability and simulation"; and finish with the fourth section, "Statistical Inference: Estimating population parameters and testing hypotheses."

The course objectives are that students will:

- use formalized procedures to collect data in experiments and surveys;
- organize and interpret information using graphical displays and summary statistics;
- understand the basic concepts of probability and use probability theory to predict outcomes of random events;
- learn a variety of statistical tests and estimation procedures and understand which is appropriate for a particular study;
- use statistical data and reasoning skills to make inferences and communicate them in a clear written format;
- read and analyze articles and studies from current news sources and apply statistical methods to assess validity; and
- organize, summarize, and effectively present collected data using technology, including graphing calculators and computers.

Course Planner

Vacation days and student-released days are not included in the days of instruction. Thanksgiving usually occurs around day 60, winter break near day 73, and spring break just after day 134. In the chart below, FRQ refers to an AP Exam free-response question (available on AP Central). The 1997 questions are from the printed Released Exam. The newspaper articles cited are ones that I have accumulated over the years. Most of the time I just read the article to the class, although in some cases I make photocopies. HW means homework; throughout, the decimal numbers following "HW" refer to problem numbers.

SEMESTER 1

Day	Section and Title	Activities/Assignments
1	The Role of Statistics (chapter 1)	Class: Sexual discrimination activity HW: Read pp. 1–10; problems 1.1–7
2	Types of Data (2.1)	HW: 2.1–2.4
3	Sampling (2.4)	Class: Gettysburg Address activity—use Rossmanchance.com's Sampling Words (see the Teacher Resources section of this syllabus) HW: Read pp. 20–22; article and questions: "Polling's Dirty Little Secret," Week in Review, *New York Times*, Nov. 21, 1999

Day	Section and Title	Activities/Assignments
4	Bias in Sampling (2.4)	Class: "Putting a Reality Check on 'Holocaust Denial,' " *USA Today*, Jan. 12, 1994 HW: 2.16, 2.19–22
5	Random Sampling (2.4)	HW: 2.11, 2.12; article and questions: "How to Tell if Political Polls Are About Truth, or Consequences," *Los Angeles Times*, Jan. 30, 2000
6	Stratified Random Samples (2.4)	Class: Use NCSSM's "Rolling Down the River" (see Teacher Resources section) HW: 2.10, 2.13, 2.17, 2.18
7	Other Sampling Methods (2.4)	Class: FRQ, 2004B no. 2 HW: Sampling worksheet
8	Experiments and Observational Studies (2.2–2.3)	HW: Read pp. 15–19, problems 2.5, 2.7–9
9	Designing Experiments (2.5)	HW: Read pp. 27–35; worksheet: Wildcat Arena. (I give students a drawing of a basketball arena—different levels, different sections—and then ask them to use each of the sampling methods we have learned to get a sample of people from the arena.)
10	Designing Experiments, continued (2.5)	HW: 2.23, 2.25, 2.26
11	More Designing Experiments (2.5)	Class: FRQ, 1999 no. 3 HW: 2.28–30, 2.32
12	Scope of Inference (2.5)	HW: Articles and questions: "Study: Clot-busters Work in Lungs, Too," *Herald-Sun* (Durham, N.C.), Aug. 5, 1997; "Study: Schizophrenia Drug May Help Alzheimer's Patients," *Herald-Sun* (Durham, N.C.), Dec. 11, 1997
13	Caffeine Experiment (2.5)	Class: FRQ, 2000 no. 5 HW: 2.33, 2.36, 2.38–40
14	Review: chapter 2	Class: FRQ, 2006B no. 5 HW: Articles and questions: "Duke Study Measures Prayer's Healing Effects," *Herald-Sun* (Durham, N.C.) Nov. 10, 1998; "Brisk Walks Can Lengthen Your Life, Study Finds," *Herald-Sun* (Durham, N.C.), Feb. 11, 1998
15	Test: chapter 2	
16	Displaying Categorical Data: Bar and Pie Charts (3.1)	HW: 3.2, 3.3, 3.7, 3.10, 3.11
17	Displaying Numerical Data: Dotplots and Stem-and-Leaf Displays (3.2)	HW: 3.12, 3.15–20
18	Displaying Numerical Data: Frequency Distributions and Histograms (3.3)	HW: 3.32–34, 3.36

Day	Section and Title	Activities/Assignments
19	Cumulative Relative Frequency Distributions (3.3)	Class: FRQ, 2006 no. 1 HW: chapter 3 worksheet
20	Describing the Center of a Data Set (4.1)	HW: 4.2, 4.3, 4.5–7, 4.9, 4.16, 4.17
21	Measures of Spread (4.2)	Class: FRQ, 2006B no. 1 HW: 4.19, 4.21, 4.25
22	More Measures of Spread/Boxplots (4.2–4.3)	HW: 4.29–33
23	More on Standard Deviation/Using the TI-83 (4.4)	Class: FRQ, 2005 no. 1 HW: 4.22–24, 4.34
24	More on Standard Deviation (4.4)	HW: 4.35–41, 4.44
25	Shifting and Rescaling Data (not in book)	HW: Read pp. 135-37; problems 3.46, 3.49, 4.51, 4.52, 4.58, 4.59, 4.61, 4.64
26	Review: chapters 3 and 4	Class: FRQ, 2004 no. 1; matching distributions (from *Activity-Based Statistics*) HW: *JMP* Student Edition worksheet (see the Teacher Resources section)
27	Test: chapters 3 and 4	
28	Describing Bivariate Data with Scatterplots (5.1–5.2)	HW: 5.1–9, odd
29	Fitting a Line to Bivariate Data (5.3)	Class: Use Geometer's Sketchpad's "Least Squares" applet (see the Teacher Resources section) HW: 5.26, 5.27, 5.29, 5.30
30	Assessing the Fit of a Line (5.4)	HW: 5.47, 5.48
31	How Accurate Will Our Predictions Be? (5.4)	Class: FRQ, 1998 no. 2 HW: 5.38a–d + residual plot; 5.39a, b; 5.43a, d
32	5.4 continued	HW: 5.40–42, 5.44–46, 5.49
33	Understanding Regression Output (5.4)	HW: Regression output worksheet
34	Correlation (5.2)	HW: 5.10–12, 5.14, 5.16–18
35	Regression (5.3)	HW: 5.31–35
36	Unusual and Influential Points (5.4)	Class: Use "Linear Regression" applet (see the Teacher Resources section) HW: Review worksheet
37	Review: chapter 5	Class: Introduce first-semester project Class: FRQ, 1999 no. 1 HW: Work on project proposals
38	Review: chapter 5	Class: FRQ, 2005 no. 3

Day	Section and Title	Activities/Assignments
39	Test: chapter 5	
40	Review for midterm	Class: FRQ, 2006 no. 5
41	Review for midterm	Class: Use NCSSM's "The Midge Problem" (see the Teacher Resources section)
42	Review for midterm	Class: Midge problem
43	Review for midterm	Class: Collect project proposals Class: FRQ, 2005 no. 1
44	Midterm	
45	Chance Experiments and Events (6.1)	HW: 6.1–3, 6.5, 6.12
46	Definition of Probability (6.2)	HW: 6.8, 6.9, 6.11, 6.13
47	Basic Properties of Probability (6.3)	HW: 6.15–18, 6.20, 6.21, 6.24, 6.26, 6.27
48	Conditional Probability (6.4)	HW: 6.29–35
49	Independence (6.5)	HW: 6.36–44
50	6.5 continued	Class: FRQ, 2003B no. 2 HW: 6.45–52
51	Some General Probability Rules (6.6)	HW: 6.53–61
52	Review: 6.1–6.6	HW: 6.62–69
53	Estimating Probabilities Using Simulation (6.7)	HW: Read pp. 285-91; problem 6.71; simulation worksheet, problems 1–2
54	More Simulations (6.7)	HW: Simulation worksheet, problems 3–4
55	More Simulations (6.7)	HW: 6.75 (do five runs); simulation worksheet, problem 5
56	Review: chapter 6	HW: Review worksheet, problems 1–5
57	Review: chapter 6	Class: FRQ, 2001 no. 3
58	Test: chapter 6	
59	Project presentations	
60	Project presentations	
61	Discrete Random Variables (7.1–7.2)	Class: Start penny activity and continue daily (from *Activity-Based Statistics*) HW: 7.1–11
62	Continuous Random Variables (7.3)	HW: 7.12, 7.14, 7.17, 7.20–26
63	Mean of a Random Variable (7.4)	HW: 7.28, 7.35; worksheet, problems 1–3
64	Standard Deviation of a Random Variable (7.4)	HW: 7.32, 7.33, 7.36, 7.37

Day	Section and Title	Activities/Assignments
65	Linear Functions and Linear Combinations (7.4)	HW: 7.29, 7.30, 7.34, 7.40
66	7.4 continued	Class: FRQ, 2001 no. 2 HW: 7.38, 7.39, 7.41; worksheet, problem 4
67	Binomial Distribution (7.5)	HW: 7.43, 7.44, 7.46
68	More on the Binomial Distribution (7.5)	HW: 7.47, 7.49–52, 7.54
69	Geometric Distribution (7.5)	HW: 7.55–58
70	Review: 7.1–7.5	Class: FRQ, 2005B no. 2 HW: Worksheet, 5–7
71	The Normal Distribution (7.6)	HW: 7.61, 7.62, 7.64, 7.65 (include illustrations)
72	Other Normal Distributions (7.6)	HW: 7.66–70
73	Using TI-83 Distribution Menu (7.6)	HW: 7.71–75
74	Combining Normal Random Variables (7.6)	HW: Worksheet, problems 8–9
75	Normal Approximation to the Binomial Distribution (7.8)	HW: 7.94 (use normal approximation), 7.115-19; worksheet, problem 10
76	Review: chapter 7	Class: FRQ, 2006B no. 3 HW: 7.98–100, 7.102, 7.104, 7.114
77	Review: chapter 7	Class: FRQ, 2004 no. 4
78	Test: chapter 7	
79	Sampling Distributions (8.1)	HW: 8.1–4, 8.8
80	How Many Textbooks? (8.1)	Class: Textbook activity (see the Student Activities section of this syllabus) HW: 8.7–10
81	Sampling Distribution of the Sample Mean (8.2)	Class: Finish penny activity Class: Use “Sampling Distribution” applet at Rice Virtual Lab in Statistics (see the Teacher Resources section) HW: 8.14–16, 8.20, 8.23, 8.24
82	Sampling Distribution of a Sample Proportion (8.3)	HW: 8.27–33
83	Review: chapter 8 / textbook activity	HW: 8.34–40
84	Review: chapter 8 / textbook competition	

Day	Section and Title	Activities/Assignments
85	Test: chapter 8	HW: FRQs, 1998 nos. 4, 6; 2002B nos. 3, 5; 2006 no. 3
86	Review for final	
87	FINAL EXAM	

SEMESTER 2

88	Estimation Using a Single Sample (9.1)	HW: 9.1–3, 9.8, 9.9
89	Large-Sample Confidence Interval for a Population Proportion (9.2)	HW: 9.12, 9.14, 9.15, 9.20
90	9.2 continued	HW: 9.10, 9.11, 9.19, 9.23, 9.25, 9.27
91	Interpreting the Confidence Level (9.2)	Class: Confidence interval activity HW: 9.13, 9.22, 9.24, 9.26, 9.28
92	Confidence Interval for a Population Mean (9.3)	HW: 9.34, 9.46–48
93	Confidence Intervals for a Population Mean When σ Is Unknown (9.3)	HW: 9.30, 9.31, 9.38, 9.40, 9.44
94	9.3 continued	Class: FRQ, 2002B no. 4 HW: 9.32, 9.33, 9.41, 9.43, 9.45
95	Review: chapter 9	Class: FRQ, 2000 no. 2 HW: 9.50–53, 9.55
96	Test: chapter 9	
97	Hypothesis Testing (10.1)	HW: 10.1, 10.2, 10.4–9
98	Errors in Hypothesis Testing (10.2)	HW: 10.10–16
99	Hypothesis Tests for a Population Proportion (10.3)	Class: Simulation activity HW: 10.17–23
100	10.3 continued	Class: FRQ, 2003 no. 2 HW: 10.27–29
101	10.3 continued	HW: 10.31, 10.32, 10.36
102	10.4 Hypothesis Tests for a Population Mean	HW: 10.41, 10.43, 10.44, 10.46, 10.47
103	10.4 continued	Class: FRQ, 2005 no. 4 HW: 10.42, 10.45, 10.50, 10.53, 10.54
104	Power (10.5)	HW: 10.56, 10.65, 10.67, 10.70
105	Review / *JMP* activity	HW: 10.69, 10.73, 10.74

Day	Section and Title	Activities/Assignments
106	Review / *JMP* activity	Class: FRQ, 2005B no. 6 HW: *JMP* activity
107	Test: chapter 10	
108	Inferences Concerning the Difference Between Two Population or Treatment Means Using Independent Samples (11.1)	Class: Fish oil activity (see the Student Activities section) HW: Read pp. 535-47
109	11.1 continued	HW: 11.6, 11.18, 11.24
110	11.1 continued	Class: FRQ, 2000 no. 4 HW: 11.8, 11.14, 11.21, 11.23
111	Confidence Intervals for the Difference of Two Means (11.1)	HW: 11.12, 11.28
112	Inferences Concerning the Difference Between Two Population or Treatment Means Using Paired Samples (11.2)	HW: 11.33, 11.34, 11.37, 11.43
113	Confidence Intervals for Paired Data (11.2)	HW: 11.32, 35, 38, 40
114	Inferences Concerning a Difference Between Two Population or Treatment Proportions (11.3)	HW: 11.45–47
115	Confidence Intervals for the Difference of Two Proportions (11.3)	Class: FRQ, 2001 no. 5 HW: 11.48, 11.50, 11.55, 11.57
116	Introduce TI-83 test menu	HW: 11.70, 11.74, 11.76, 11.85
117	Review: chapter 11	Class: FRQ, 2006B no. 2
118	Test: chapter 11	
119	Review for midterm	HW: FRQs, 1997 no. 4; 1998 no. 1; 2004 no. 6
120	Review for midterm	HW: FRQs, 1998 no. 10; 2005B no. 4; 2006 no. 4
121	Midterm (chapters 8–11)	
122	Chi-Square Tests for Univariate Categorical Data (Goodness of Fit Tests) (12.1)	Class: M&M's activity HW: 12.1, 12.5, 12.6, 12.13 (calculations only!)
123	12.1 continued	HW: 12.8–10
124	Chi-Square Tests for the Homogeneity of Proportions (12.2)	HW: 12.15, 12.17, 12.28, 12.29

Day	Section and Title	Activities/Assignments
125	More HOP Tests (12.2)	Class: FRQ, 2003B no. 5 HW: 12.23, 12.30; article: "The Role of Suggestion in the Perception of Satanic Messages in Rock-and-Roll Recordings," *Journal of Psychology* 116 (1984): 245-48.
126	Chi-Square Tests for Independence (12.2)	HW: 12.16, 12.21, 12.24, 12.27
127	Review: chapter 12	HW: 12.32, 12.33; article: "Sex and Time of Day as Determinants of Whether People Enter the Cafeteria Together or Alone," *Psychological Reports* 51 (1982): 837-38.
128	Review: chapter 12	Class: FRQ, 1999 no. 2
129	Quiz: chapter 12	
130	General Regression Model (13.1)	HW: 13.1, 13.3, 13.6, 13.8
131	Inference for the Slope of a Least-Squares Line (13.2)	HW: 13.21, 13.25
132	Confidence Intervals for the True Slope (13.2)	HW: 13.19, 13.22, 13.26
133	Understanding Computer Output	HW: *JMP* Student Edition worksheet (13.24) (See Teacher Resources section)
134	Review: section 13.2	Class: FRQ, 2005B no. 5 HW: FRQs, 2001 no. 6; 2006 no. 2
135	Modeling Nonlinear Data (5.5)	HW: Worksheet, problems 1–2
136	More Nonlinear Data (5.5)	HW: Worksheet, problems 3–4
137	More Nonlinear Data (5.5)	HW: Worksheet, problems 5–7
138	Conclusion (5.5)	Class: FRQ, 2004B no. 1 HW: FRQ, 1997 no. 6
139	Quiz: chapter 13, 5.5	
140	Review for final	Use remaining FRQs (from AP Central and the Released Exams) Evening: complete practice AP Exam (2002)
141	Review for final	Use remaining FRQs
142	Review for final	Use remaining FRQs
143	Final exam	
144	Final exam	
145	Review for AP Exam	Use remaining FRQs
146	Review for AP Exam	Use remaining FRQs
147	Review for AP Exam	Use remaining FRQs
148	**AP Exam**	

Day	Section and Title	Activities/Assignments
149	Assign second-semester project	
150	Multiple Regression (14.1)	HW: 14.4–7
151	Fitting a Model and Assessing Its Utility (14.2)	HW: 14.16, 14.25
152	Inferences Based on an Estimated Model (14.3)	Class: Collect project proposals HW: 14.37, 14.38
153	Other Issues in Multiple Regression (14.4)	HW: 14.52, 14.54, 14.56, 14.58, 14.62
154	More Multiple Regression (14.4)	HW: Multiple regression worksheet
155	More Multiple Regression (14.4)	HW: Multiple regression models for used cars
156	Logistic Regression (not in book)	HW: Logistic worksheet, problems 1–2
157	Multiple Logistic Regression (not in book)	HW: Logistic worksheet, problems 3–4
158	Single-Factor ANOVA (15.1)	
159	Single-Factor ANOVA (15.1)	HW: 15.5, 15.17
160	Using *JMP* Student Edition for ANOVA (15.1)	HW: 15.28, 15.29
161	ANOVA for Randomized Blocked Experiments and Multifactor Studies (15.2)	HW: 15.35, 15.37
162	Using *JMP* Student Edition (15.2) / review: chapters 14 and 15	HW: 14.73, 15.38, 15.63
163	Review: chapters 14 and 15	
164	Test: chapters 14 and 15	
165	Project presentations	
166	Project presentations	
167	Project presentations	

Teaching Strategies

On a normal day, class starts with a review of the homework from the previous evening. This is usually followed by a presentation of new material. To help students assimilate the large amounts of information imparted, I provide them with partially complete notes (see the example below). Students download these from my school Web site for each chapter, print them out, and bring them to class daily. Depending on the topic, the notes may include exposition with key words left out, examples, and/or problems for practice. The practice problems are to be done in class so I can check for understanding. This routine has freed up an average of 15 minutes in every class period. I use the additional time in a variety of ways: to read articles from newspapers and magazines (see the Course Planner above), to have extended discussions about the lesson, and to work on practice AP Exam free-response questions.

Example of Partially Complete Notes

The following lesson plan takes approximately two full class periods, plus an additional class period to conduct the experiment (the best part). What appears below is the teacher's version. In the students' version, everything that is <u>underlined</u> or in *italics* would be left blank.

Experimental Design

Suppose we wanted to design an experiment to see if caffeine affects pulse rate.

What is the explanatory variable?

- *Caffeine*

What is the response variable?

- *Pulse rate*

Who will be the experimental units?

- *The students in this class*

Here is an initial plan:

- Measure initial pulse rate.
- Give each student some caffeine.
- Wait for a specified time.
- Measure final pulse rate.
- Compare final and initial rates.

What are some problems with this plan?

- *If there is a change in pulse rates, we do not know if caffeine was the cause. For example, suppose I told a joke while we were waiting, and everyone laughed so hard that his or her pulse rate went up. Or, suppose we took notes and everybody's pulse rate slowed down to sleeplike levels. Finally, there are any number of other things that could occur that we may not be aware of.*

Some problems can be easily solved by including a control group, which does not receive caffeine. In our experiment, we can accomplish this by using two levels of caffeine: no caffeine and some caffeine. For example, we could assign each class member to one of two treatments: regular cola or caffeine-free cola. Caffeine-free cola is considered a placebo, which is a treatment that is lacking the explanatory variable but is similar to the other treatments in every other way.

Why do we not give cola to one group and nothing to the other group?

- *Oftentimes applying any treatment can create a change in the response variable. For example, when children get hurt, they feel better if their wound is kissed or covered with a bandage, even though neither of those treatments actually eliminate any pain.*

In our study, if only one group got a treatment, the fact that its members were chosen to receive free soda might make their pulses increase before the caffeine even hits their bloodstream! Having every subject receive a treatment ensures that both groups think they are being treated the same. Then, any difference between their pulse rates can be attributed to the explanatory variable and not the excitement of getting free soda.

Of course, it is essential that the subjects do not know which treatment they are receiving. If a person does not know who is receiving which treatment, that person is blind.

There are two classes of individuals who can influence the results of an experiment:

- *Those who could influence the results directly (subjects, treatment administrators, and the like)*
- *Those who evaluate the results*

When every individual in one of these classes is blinded, the experiment is called single blind. If every individual in both classes is blinded, then the experiment is double blind.

Can our experiment be run in a double blind manner?

- *Yes, if the subjects, the people handing out the treatments, and the people measuring the pulse rates all do not know which treatment is which.*
- *But doesn't someone need to know which is which? Yes, but that person should not have any interaction with the subjects at any point of the experiment.*

Four Key Principles of a Good Experiment

Our overarching goal when designing an experiment is to make the treatment groups as similar as possible—with the exception of the treatments themselves—and to keep extraneous variables from affecting the treatment groups differentially while the experiment is going on. Then, if there is a change in the response, it can be attributed to the explanatory variable and not to any extraneous variables.

An extraneous variable is one that is not of interest in the current study but is thought to affect the response variable. For example, sugar is an extraneous variable, as it may affect pulse rates. If one treatment group was given regular cola and the other treatment group was given caffeine-free diet cola, then sugar and caffeine would be confounded. If there was a difference in the average pulse rates of the two groups after receiving the treatments, we would not know which variable caused the change, and to what extent. To prevent sugar from becoming a confounding variable, we need to make sure that both treatment groups get the same amount of sugar.

Principle 1: Direct control means holding extraneous variables constant for all treatment groups so that their effects are not confounded with the explanatory variable.

- *Temperature of drink*
- *Size of drink*
- *Drinking rate*
- *Amount of sugar (no diet soda)*
- *Waiting time between treatment and pulse reading*
- *Pulse rate before experiment (need to be resting)*
- *Room temperature*
- *Amount of carbonation*
- *How we measure pulse*

If we do not control these extraneous variables by making them the same for all treatment groups, they could have differential effects on the response variable and thus confound the effects of the caffeine on pulse rates. For example, we may not be able to tell if it was the caffeine or the temperature that causes the higher pulse rate.

Principle 2: Blocking occurs when subjects are divided into blocks (groups) of similar units based on some extraneous variable and then separated into different treatment groups.

What if men react to caffeine differently than women?

- *This additional variability may make it more difficult to see the difference between the treatments.*

Can we eliminate this source of variability?

- *We could run the study with only one gender to exert direct control, but then we could only draw conclusions about one gender.*
- *But, to reduce this variability we could make sure there is a representative number of men and women in each treatment. For example, if there are 20 women and 30 men in the experiment, then the experimental group should have 10 women and 15 men, and the control group should have the same.*
- *In this example, we have formed two blocks: men and women. Then we assigned both treatments to the subjects within each block.*

Blocking in experiments is similar to stratification in sampling.

- Blocking reduces the variability of the results, just as stratifying does.
- Blocks should be chosen in the same manner as strata: the units within the block should be similar but different from the units in the other blocks. You should only block when you expect that the subjects in one block will have a different response than subjects in other blocks.

What are some other extraneous factors that we can block for?

- *Age, weight, initial pulse rate, etc.*

You should try to make the blocks as small as possible. Ideally, the size of the block should be the same as the number of treatments. For example, if there are three treatments, then there should be three subjects in each block. If each block has only two subjects, then the subjects are called a matched pair.

Principle 3: Randomization is the random assignment of subjects to treatments to ensure that the experiment does not systematically favor one treatment over the other.

What about all of the other extraneous variables we do not think of? What about the variables we cannot directly control or block for?

- *Amount of food eaten before the experiment*
- *Caffeine tolerance*

If we randomly assign subjects to treatments, this should, on average, even out (but not necessarily eliminate) the differential effects of these variables, because their effects should be spread equally between the treatment groups.

Note: We must always randomize, as there will always be extraneous variables we do not consider.

How do we randomize?

- *Draw names from a hat. The first half chosen are in one group, the remaining names in the other.*
- *Number the class members from 1 to 36. Then, generate random numbers without replacement until half are chosen for one group. The remaining subjects go in the other group.*
- *For matched pairs, flip a coin to determine which subjects go into which group. If the coin comes up heads, the first person in the pair goes to group A and the other person to group B; if it comes up tails, the first person goes to group B and the other person to group A.*

Principle 4: Replication means ensuring that there are an adequate number of observations in each treatment group. If each treatment group only had one experimental subject, then we would not be able to conclude that any changes in the response are the result of the treatments. It is possible that some characteristic of the individual was the cause of the change.

Increasing the sample size makes randomization more effective. The more subjects we have, the more balanced our treatment groups will be. For example, if we have only 10 subjects and 2 of them have a certain unknown characteristic, it is quite likely that both of those subjects could end up in the same treatment group, simply by chance. However, if we have 100 subjects and 20 have the characteristic, it is very unlikely for all 20 to end up in the same group. There is a much better chance that the groups will be close to balanced (10/10, 9/11, 11/9, etc.) when the sample size is larger. (If you were flipping a coin and wanted to get as close as possible to 50 percent, you would flip the coin more than a few times!)

Note: Replication can also refer to repeating the experiment with different subjects. This can help us feel more confident about applying the results of our experiment to a wider population.

Summary: With control, blocking, randomization, and replication, each treatment group should be nearly identical, and the effects of extraneous variables should be the same in each group. Now, if changes in the explanatory variable are associated with changes in the response variable, we can conclude that it is a cause-and-effect relationship.

After completing this lesson, we conduct the experiment in class. I bring in cola with caffeine and without caffeine (whatever brand is on sale) in the same cooler so the temperatures will be the same. Volunteers from the class help me pour equal amounts of soda into identical cups. There are usually a few students who do not drink soda, so make sure to let everyone know that participation is voluntary. The rest of the students measure their initial pulse rates and form two lines: males (ordered by pulse rates) and females (ordered by pulse rates). The first two males are paired, the next two males are paired, and so on. I flip a coin to assign each pair to treatments. If the coin comes up heads, the first person goes to the left side of the room and the other person goes to the right; if it is tails, vice-versa. The same is done for the female line.

Then each group is given a different treatment. The students slowly drink the soda while we go over a homework assignment. After about 15 minutes, each student measures his or her final pulse rate. We compare the change in pulse rates for each pair, but because this is only the first semester, we do not do any formal inference procedures. One additional twist (that I discovered by accident one year) is to leave the door to the classroom open so that the two groups will be in slightly different environments. This is a perfect example of a confounding variable: if there is a difference in pulse rates, we will not know if it is due to the difference in caffeine content or the difference in environment.

One final note: in 11 years of doing this experiment, the results have never appeared significant. This is probably because the amount of caffeine in a cup of soda is too small to make a measurable difference.

Preparing Students for the AP Exam

I use several strategies to help students get ready for the AP Exam:

- I give a cumulative midterm and final each semester, with the second-semester final usually given a week *before* the AP Exam.
- Students come in during the evening or on Saturday approximately two weeks before the final exam to take the entire 2002 AP Exam. We score the exam together immediately afterward.
- During the year, students work in groups of four to complete previous AP Exam free-response questions, usually on a topic we are currently studying. Each member of the group is responsible for discussing the answers to the question and making sure the other group members understand. They are allowed to use their notes and textbook. Each student writes up his or her answer, and the group turns in all four papers together. I randomly select one paper to grade and give the entire group the same score, based on the scoring guidelines found on AP Central. These questions are worth 5 percent of a student's semester grade, and I usually value them at 3 points instead of 4, as AP questions can be quite challenging.
- Some students choose to purchase an AP Statistics review book (see the Teacher Resources section below), but this is not required, and we do not use them in class.

Use of Technology

- All students have a TI-83/TI-83 Plus/TI-84 graphing calculator for use in class, at home, and on the AP Exam. They use it extensively throughout the course.
- All students have a copy of *JMP* Student Edition statistical software for use at home and for demonstrations in class. I give them occasional assignments that must be completed using this program. After the AP Exam, they use this software daily when we learn multiple regression and ANOVA. Other statistical software such as *Fathom* and *Minitab* is used for demonstration purposes. Although *JMP* is packaged with some textbooks, our school obtained it independently.
- In class, I make use of a variety of applets available on the Internet (see my Teacher Resources section).

Student Evaluation

Each student receives two semester grades, not one overall grade. Progress reports are sent out at 6 and 12 weeks, but each semester's grades accumulate and are not an average of each 6-week period. The semester grades are determined as follows:

Tests: 65 percent

Each semester there are approximately eight tests, one for each chapter, as well as cumulative midterms and finals. A significant portion of each test assesses communication skills and connections between topics.

Homework: 15 percent

Students are assigned daily homework from the primary textbook.

Projects: 10 percent

Each semester students complete a major project (see my Student Activities section).

Participation: 5 percent

Participation in class discussions and activities is required.

Class work: 5 percent

This consists of AP Exam free-response questions done in groups and other in-class activities.

The midterm is weighted the same as the other tests. The final is longer (two hours versus one hour), so it is worth more points but proportionally so. In other words, a multiple-choice question is still worth the same on the final; however, there are more of them. The format of all the tests is similar—roughly one-third to one-half multiple-choice questions and the rest free-response questions. I try to make them similar in format to the AP Exam.

The grading scale at Wilson High is as follows: A = 90–100, B = 80–89, C = 70–79, D = 60–69.

Teacher Resources

Basic Textbook

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. Pacific Grove, Calif.: Brooks/Cole, 2001.

Exam Review Books

Bohan, James F. *AP Statistics: Preparing for the Advanced Placement Examination*. New York: AMSCO, 2000.

Carroll, Anne M., Ruth E. Carver, Susan A. Peters, and Janice D. Ricks. *Preparing for the Statistics AP Exam with "Stats: Modeling the World," 2nd ed.* AP Test Prep series. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2007.

Hinders, Duane C. *5 Steps to a 5: AP Statistics*. New York: McGraw-Hill, 2004.

Levine-Wissing, Robin, and David Thiel. *AP Statistics*. 3rd ed. Piscataway, N.J.: Research and Education Association, 2006.

Sternstein, Martin. *Barron's AP Statistics: How to Prepare for the Advanced Placement Exam*. 3rd ed. Hauppauge, N.Y.: Barron's Educational Series, 2004.

Other Texts and Resource Books

Agresti, Alan, and Christine Franklin. *Statistics: The Art and Science of Learning from Data*. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2007.

Albert, Jim, and Jay M. Bennett. *Curve Ball: Baseball, Statistics, and the Role of Chance in the Game*. New York: Springer, 2001. An introduction to statistics using baseball.

Bock, David E., Paul F. Velleman, and Richard D. De Veaux. *Stats: Modeling the World*. 2nd ed. Boston: Pearson/Addison-Wesley, 2007.

College Board. 1997 *AP Statistics Released Exam*. New York: College Board, 1997.

College Board. 2002 *AP Statistics Released Exam*. New York: College Board, 2002. (Note: The 2007 Released Exam has become available since this syllabus was submitted.)

Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. 2nd ed. Belmont, Calif.: Thomson Brooks/Cole, 2005.

Ramsey, Fred L., and Daniel W. Schafer. *The Statistical Sleuth: A Course in Methods of Data Analysis*. 2nd ed. Pacific Grove, Calif.: Thomson/Duxbury, 2002.

Rossman, Allan J., Beth L. Chance, and J. Barr von Oehsen. *Workshop Statistics: Discovery with Data and the Graphing Calculator*. 2nd ed. Emeryville, Calif.: Key Curriculum Press, 2002. Versions to use with *Fathom*, *Minitab*, and other software packages are also available.

Salsburg, David. *The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century*. New York: W. H. Freeman, 2001. A very readable introduction to the history of statistics.

Scheaffer, Richard L., Mrudulla Gnanadesikan, Ann Watkins, and Jeffrey A. Witmer. *Activity-Based Statistics*. New York: Springer, 1996.

Watkins, Ann E., Richard L. Scheaffer, and George W. Cobb. *Statistics in Action: Understanding a World of Data*. Emeryville, Calif.: Key Curriculum Press, 2003.

Yates, Daniel S., David S. Moore, and Daren S. Starnes. *The Practice of Statistics: TI-83/89 Graphing Calculator Enhanced*. 2nd ed. New York: W. H. Freeman, 2003.

Periodicals

Chance. Magazine published quarterly by the American Statistical Association and Springer. Subscription information at www.amstat.org.

STATS: The Magazine for Students of Statistics. Published three times a year by the American Statistical Association and Springer. Subscription information at www.amstat.org.

Neither magazine is written specifically for the AP Statistics teacher, but they are both very interesting. Subscription prices are discounted for ASA members.

Software

ActivStats. CD-ROM ed. 2005-06 release by Paul Velleman. N.p.: Addison-Wesley, 2006.
www.datadesk.com/products/mediadx/activstats.
Data Desk analysis software is built into this product.

Fathom Dynamic Data Software. Version 2. Emeryville, Calif.: Key Curriculum Press.
www.keypress.com.

JMP 6. Student Edition.
www.JMP.com/se.

Minitab.
www.minitab.com.

StatCrunch: Data Analysis on the Web.
www.statcrunch.com.
Web-based statistical software.

WinStat.
http://math.exeter.edu/rparris.
Free download.

Videos

Against All Odds: Inside Statistics. Lexington, Mass.: Consortium for Mathematics and Its Applications (COMAP), 1989. This video series of 26 half-hour segments was written by David Moore. It can be viewed online for streaming media for free at www.learner.org. Downloading is prohibited.

Statistics: Decisions Through Data. By David S. Moore. Five videocassettes with user's guide. Lexington, Mass.: Consortium for Mathematics and Its Applications (COMAP), 1992. This series of five one-hour videos (total of 21 video segments) teaches various topics in 10–15 minute segments, using some of the footage from *Against All Odds*. The videos are useful for introducing or reviewing a topic, or for a day when a substitute covers your class. They come with worksheets and other materials.

Web Resources

AP Statistics Course Home Page.
apcentral.collegeboard.com/stats.
This is a wonderful resource that includes the Course Description, previous AP Exam free-response questions, sample syllabi, tips for the AP Exam, important announcements, reviews of textbooks and other resources, and many excellent articles about the teaching of statistics.

AP Statistics Electronic Discussion Group (EDG). The College Board's electronic discussion group for this subject, commonly referred to as the "listserv," is an open forum for discussing anything related to AP Statistics, including questions on textbook problems, how to prepare for the AP Exam, issues of pacing for different textbooks, technology questions, and questions that go beyond what we would teach our students. Register through the course home page at AP Central.

AP Statistics FAQ.
www.mrderksen.com/faq.htm.
Includes resources for new teachers and sections about the AP Exam and course content.

Geometer's Sketchpad Resource Center. Least Squares.
www.dynamicgeometry.com/javasketchpad/gallery/pages/least_squares.php.

Linear Regression.
http://statweb.calpoly.edu/bchance/applets/LRApplet.html.

Math Forum@Drexel.
http://mathforum.org/kb/forum.jspa?forumID=67.
This is a read-only searchable archive of all AP Statistics EDG messages over the past several years.

NCSSM (North Carolina School of Science and Mathematics). An Exercise in Sampling: Rolling Down the River.
http://courses.ncssm.edu/math/Stat_inst01/PDFS/river.pdf.

NCSSM. The Midge Problem: A Mathematical Modeling Example.
www.dlt.ncssm.edu/afm/lessons/midge_problem.doc.

Rice Virtual Lab in Statistics. Sampling Distribution.
http://onlinestatbook.com/stat_sim/sampling_dist/index.html.

Rossmanchance.com. Sampling Words.
www.rossmanchance.com/jsm03/activities/SamplingWords.doc.

Student Activities

How Many Textbooks?

(Adapted from the "How Many Taxis?" problem from the North Carolina School of Science and Mathematics [http://courses.ncssm.edu/math/Talks/PDFS/Taxis%20for%20MAA.pdf] and from the "How Many Tanks?" activity in *Activity-Based Statistics* [see citation in the Teacher Resources section above]. Sample Syllabus 3 in this publication describes how the German tank activity is used in Michael Allwood's classroom.)

During World War II, Allied forces noticed that all German tanks were labeled with a serial number. After observing numerous tanks, it became obvious that the tanks were numbered systematically. Thus, the Allies were able to predict the total number of German tanks and their locations using the observed serial numbers. This became known as the German Tank Problem (for more information, see www.guardian.co.uk/g2/story/0%2C%2C182425%2C00.html).

Fortunately for our troops in the Middle East, enemy forces do not have any tanks to speak of. However, the methods used to solve the German Tank Problem can be applied to many other situations. In this assignment, your job is to develop a method to estimate the total number of AP Statistics books (or any other textbook) at our school, based on a random sample of books and the assumption that the books are numbered sequentially starting from 1.

For example, suppose a random sample of $n = 7$ books contains the following numbers: 10, 38, 59, 61, 74, 90, 94. How can you use this information to estimate the total number of books (N)? One possible method would be to take the median value (61) and double it. In this example, $61 \times 2 = 122$. Thus, our estimate for the total number of books is $N = 122$.

For this activity you will create three other statistics to estimate the total number of books. Remember, a statistic is any quantity computed from the values in a sample. You may use any combination of the summary statistics we already know (mean, median, min, max, quartiles, IQR, standard deviation) or invent your own. The goal is to find a relatively *simple* statistic that reliably predicts the total number of books.

To determine which of your three statistics gives the best prediction, you will perform a simulation to generate sampling distributions for each of your three statistics. For the purposes of the simulation, assume that there are 100 books total ($N = 100$) and that you will be taking samples of size 7 ($n = 7$). For each run (do 25 runs), generate seven random numbers from 1 to 100, and compute the values of each of your three statistics.

What you need to turn in:

- An introduction describing the choice of your three statistics.
- Three dotplots showing the sampling distributions for each of your statistics. Make sure they are on the same scale so they can be easily compared.
- A written description/comparison of the three distributions.
- A description of which statistic you think is best and why.

Due ____________________ (one per group)

NOTE: On ____________________ we will have a competition in class to see which group has the best statistic. The nominating order will be randomly selected, and no statistic will be allowed more than once. During each round of the competition, I will secretly choose *N* and then give you a sample of *n* numbers from 1-*N*. Each group will compute the value of its statistic based on the sample of *n* numbers. The closest estimate will be awarded 3 points, the second closest will receive 2 points, and the third closest will get 1 point. After several rounds, the team with the most points will get 2 extra-credit points per member.

Fish Oil Activity

The students are given the following handout:

In a study on the "The Antihypertensive Effects of Fish Oil," researchers randomly assigned 14 male volunteers with high blood pressure to one of two treatments. The first treatment was a four-week diet that included fish oil, and the second was a four-week diet that included a mixture of oils that approximated the types of fat present in the American diet (here called "regular oil" for simplicity). The response variable was the reduction in diastolic blood pressure (mm of mercury). The results of this study are shown below. (Source: *New England Journal of Medicine* 320 [1989]: 1037-43; cited in Ramsey and Schafer, *The Statistical Sleuth*, p. 23.)

Fish oil:	8	12	10	14	2	0	0	$\bar{x}_f = 6.57$
Regular oil:	-6	0	1	2	-3	-4	2	$\bar{x}_r = -1.14$

At first glance, it appears that the average reduction when using fish oil is higher than the average reduction when using regular oil ($\mu_f - \mu_r > 0$), because $\bar{x}_f - \bar{x}_r = 7.71 > 0$. However, it is possible that the oils have the same effect and that the observed difference is the result of randomization variability.

To decide, we start by assuming that the null hypothesis is true $(H_0 : \mu_F = \mu_R)$. That is, there is no difference between regular oil and fish oil. So, the first person in the list would have had a reduction of 8 no matter which treatment he was taking. He just happened to be assigned to the fish oil group by chance.

To see how likely it is to get a difference of 7.71 because of randomization variability, we can perform a simulation. Write each reduction on a piece of paper, and re-randomize the subjects into two groups. This simulates assigning the subjects to groups when the null hypothesis is true. Once you make two new groups, find the mean of each group and then their difference $(\bar{x}_F - \bar{x}_R)$. Finally, collect differences from the class to form a sampling distribution of $\bar{x}_F - \bar{x}_R$, and estimate the probability of getting a difference as high as 7.71 by random chance.

Teacher's note:

Once each student has a difference of means, plot all the results on a dotplot. It is very unlikely that any of the differences will be more than 7.71. A typical conclusion to this activity might be worded in this way: "Thus, assuming that there is no difference in the two oils, it is very unlikely to get a difference of sample means as high as 7.71 by random chance ($p \approx 0$). Therefore, we reject the null hypothesis and conclude that fish oil helps reduce diastolic blood pressure."

First-Semester Project: Response Bias

(Adapted from an activity in *Activity-Based Statistics*)

You and your partner will design and conduct an experiment to investigate the effects of response bias in surveys. You may choose the topic for your surveys, but you must design your experiment so that it can answer at least one of the following questions:

- Can the wording of a question create response bias?
- Do the characteristics of the interviewer create response bias?
- Does anonymity change the responses to sensitive questions?
- Does manipulating the answer choices change the response?

Proposal (5 points)

- The proposal is due Monday, October 30. Late work will be penalized 20 percent per day, even if you are absent.
- The proposal is worth 20 percent of the grade, so do not treat it casually.
- If the proposal is not approved the first time, you will need to resubmit it for a reduced grade. You must attach the original proposal to any resubmissions.

In your proposal, you should do the following:

- Describe your topic and state which type of bias you are investigating.
- Describe how you will obtain your subjects (minimum sample size is 50). This must be practical!! Your population does not need to be from this school, nor should you interrupt any classes.
- Describe what your questions will be and how they will be asked, including how you will incorporate the principles of a good experiment and avoid confounding variables. Convince me that you have a good design!

Poster (17 points)

- The poster is due Monday, November 27. Late work will be penalized 20 percent per day, even if you are absent.
- The key to a good statistical poster is communication and organization. Make sure all components of the poster are focused on answering the question of interest.
- The poster should be standard size (about 23 by 28 inches) and not on foam board. Make sure it is light enough to be hung on the wall.

The poster should include the following components:

- Title (in the form of a question).
- Introduction: In the introduction you should discuss what question you are trying to answer, why you chose this topic, and what your hypotheses are.
- Data collection: In this section, describe how you obtained your data. Be specific.
- Graphs and summary statistics: Make sure the graphs are completely labeled, easy to compare, and help to answer the question of interest.
- Discussion and conclusions: In this section, state your conclusions. You should also discuss any errors you made, what you could do to improve the study next time, and so forth.
- Pictures of your data collection in progress.

Presentation (3 points)

Each pair is required to give a five-minute oral presentation to the class. Both members must participate equally and should be prepared to answer questions.

Second-Semester Project

Purpose: The purpose of this project is for you to actually do statistics. You are to: (1) form a hypothesis; (2) design a study; (3) conduct the study; (4) collect the data; (5) describe the data; and (6) make conclusions using the data.

Topics: You may do your study on any topic, but you must be able to perform all six steps listed above. Make it interesting, and note that degree of difficulty is part of the grade. For example, experiments are preferred over observational studies or surveys. Projects about response bias are not allowed. There will be a limited amount of class time for performing experiments.

Group size: You may work alone or with a partner.

Proposal (5 points)

You must have an approved project by Wednesday, May 10. To get approval, you should be able to demonstrate how your study will meet the requirements of the project. In other words, you need to clearly and completely describe your hypotheses, what test/interval you will use to analyze the results, how you will collect the data so the conditions will be satisfied, and so forth. You must also make sure that your study will be safe and ethical, if you are using human subjects. The proposal should be typed. If it is not approved, you will have to resubmit it for partial credit until it is approved.

Poster (17 points)

- The poster is due Wednesday, May 31. Late work will be penalized 20 percent per day, even if you are absent.
- The key to a good statistical poster is communication and organization. Make sure all components of the poster are focused on answering the question of interest.
- The poster should be standard size (about 23 by 28 inches) and not on foam board. Make sure it is light enough to be hung on the wall.

The poster should include the following components:

- Title (in the form of a question).
- Introduction: In the introduction you should discuss what question you are trying to answer, why you chose this topic, what your hypotheses are, and how you analyze your data.
- Data collection: In this section, describe how you obtained your data. Be specific.
- Graphs and summary statistics: Make sure the graphs are well labeled, easy to compare, and help answer the question of interest.
- Discussion and conclusions: In this section, state your conclusion (with test statistic and *P*-value), and discuss why your inference procedure is valid (that is, discuss the conditions and so forth). You should also discuss any errors you made and what you could do to improve the study next time.
- Live action pictures of your data collection in progress.
- Note: You should *not* include the "five steps" anywhere on your poster. The steps should be integrated throughout the sections above.

Presentation (3 points)
Each individual or pair is required to give a five-minute oral presentation to the class.

Examples of successful projects:

- Do students learn better in a quiet room or a room with music playing?
- What factors affect plant growth?
- Which brand of paper towel (popcorn, golf ball, whatever) is best?

Chapter 4
The AP Exam in Statistics

Like all AP courses, AP Statistics prepares students for a worldwide examination administered each year in early May. Students can earn college credit and/or placement into an advanced class at many colleges and universities by achieving a sufficiently high score on this exam. This assessment is not some formulaic vehicle that requires you to "teach to the test." Because the AP course and the AP Exam are designed by the same people—the AP Statistics Development Committee—the exam is a natural outgrowth of the course. The course goals emphasize the ability to creatively apply and implement statistical principles rather than rote memorization. Students will not be faced with "trick" questions; instead the AP Statistics Exam gives them the opportunity to showcase the college-level skills that they have learned throughout the year.

Exam Development and Scoring

Structure and Format

The development of each AP Statistics Exam takes two or more years. The three-hour exam consists of two sections: 40 multiple-choice questions in Section I (90 minutes) and 6 free-response questions in Section II (90 minutes), the last one of which is an "investigative task." Students are expected to have a graphing calculator with statistical capabilities available for the entire exam, and they will always have access to probability tables and a formula list. It is strongly suggested that students use these tables and the formula list throughout the year so they become familiar with the layout. These materials can be found in the published Released Exams, the Course Description, or the free-response questions available on the AP Statistics Exam Page on AP Central. They are also included with the Statistics Practice Exam available at AP Central as a free PDF download to instructors who have an authorized course syllabus.

College faculty who teach the introductory statistics courses that the AP course is intended to replicate write multiple-choice questions for Section I based on the course Topic Outline. These questions are reviewed by ETS content experts and then field-tested in college classes to obtain an estimate of their level of difficulty. The field-testing also helps to identify multiple-choice questions whose performance does not satisfy the statistical specifications of the exam. Once a question has been vetted and is in an acceptable form, it goes into the pool for future exams.

The 40 questions for Section I are assembled according to specifications developed by the Development Committee. These specifications include details as to how the multiple-choice questions in an exam should be distributed with respect to content and level of difficulty. After several further content, editorial, and fairness/sensitivity reviews, the questions are ready for printing and administration.

On the other hand, individual committee members write most of the free-response questions for Section II. The committee and the content experts review and refine these draft questions and determine which will work best for the AP Exam—will the questions accurately test the course content, do they offer the appropriate level of difficulty, and will they elicit answers that allow readers to discriminate among responses along a particular scoring scale? To ensure alignment between the free-response questions and how those questions will be scored, draft scoring guidelines are developed by the Chief Reader, a college professor who oversees the scoring of the questions, with input from the Development Committee.

The AP Reading

The multiple-choice section of the AP Exam is scanned and scored by computer. The free-response questions are evaluated at the AP Reading in June.

The people who score the free-response questions on the exam are known as Readers. These are experienced statistics instructors who teach the AP course in a high school or the equivalent course at a college or university. To ensure a broad and balanced group of Readers, factors such as school locale and setting (urban, rural, etc.), gender, ethnicity, and years of teaching experience are considered. Reader applications can be completed online at apcentral.collegeboard.com/readers. It is generally expected that applicants will have at least three years of experience teaching AP Statistics.

Some of the more experienced Readers are invited to serve as Exam Leaders (for some subjects that have two exams), Question Leaders (who supervise the scoring of a specific free-response question), and Table Leaders. The remaining Readers are divided into groups of six or eight, with each group supervised by one Table Leader. Under the guidance of the Chief Reader, the Exam Leaders, Question Leaders, and Table Leaders assist in establishing scoring standards, selecting sample student responses that exemplify those standards, and preparing for the training of the Readers.

The primary goal of the scoring process is to have each Reader score the student responses consistently, fairly, and to the same standard as the other Readers. In other words, a student response should receive the same score without regard to which Reader scored the response or the day on which it was scored. This goal is achieved through the creation of detailed scoring guidelines, thorough training of all Readers, and the various “checks and balances” that are applied throughout the Reading. For example, many but not necessarily all student responses will be “back-read” a second time by a Table Leader to ensure that the guidelines are being applied consistently. In addition, no Reader will score more than one question from a particular student’s exam.

Scoring Guidelines for the Free-Response Questions

Well before the AP Reading, the Chief Reader prepares a detailed draft of the scoring guidelines (commonly referred to as “the rubric”) for each free-response question. These guidelines are reviewed several times at Development Committee meetings throughout the year.

The Chief Reader and other Reading leadership and the content experts meet at the AP Reading site a few days before the Reading begins. They review and revise the draft scoring guidelines and test their utility by prescoring randomly selected student papers. If problems or ambiguities become apparent, the scoring guidelines are further refined and revised until a final consensus is reached. These standards allow for consistent scoring of free-response questions, including those in which different approaches are correct.

Before a question is scored, the rubric refinement team for that question conducts a training session for the Readers so that they are able to assess the question in a reliable and consistent manner. Because a Reader might score two, and perhaps three, of the six questions over the course of the Reading, there are retraining sessions when Readers switch to a different question. It is also worth noting that new Readers do not operate in a vacuum. They are paired with an experienced Reader who, along with the Table Leader, can answer any questions they may have during the process and generally help them get their feet on the ground.

You are encouraged to read chapter 1, "The AP Process," in any of the Released Exam publications for additional detailed information about the development and scoring of the exams, the creation of the scoring guidelines, and the training of Readers.

Holistic Scoring

The six free-response questions on the AP Statistics Exam are scored "holistically"; that is, each response is evaluated as a complete package. With holistic scoring, a judgment is made about the overall quality of the student's response, as opposed to "analytic" scoring, wherein the necessary components of a student's response are specified in advance, and each component is given a value counting toward the overall score. For example, suppose a student is to solve a quadratic equation, $x^2 - 2x = 7$. An analytic scoring rubric might allocate a total of 4 points in the following manner:

Score 1 point for rewriting the equation as $x^2 - 2x - 7 = 0$.

Score 1 point for correctly choosing the quadratic formula.

Score 1 point for correct substitution of the coefficients into the formula.

Score 1 point for the correct answer.

Analytic scoring is appropriate for evaluating responses to focused questions that have few response alternatives.[9] Holistic scoring, in contrast, is well suited for questions where the student is required to synthesize information and respond at least partly in written paragraphs. For example, an open-ended question may present a "real-life" experiment with resulting data and ask the student not only to analyze the data but also to comment on how the experimental protocol might be enhanced. Opinions on improvement might focus on refining the sampling method, controlling confounding variables, or seeking more power through increasing the sample size. Indeed, the student's justification of his or her experimental improvement could even depend on relevant contextual knowledge brought to the exam from the real world! In this context, holistic scoring represents a recognition not only of multiple reasonable approaches to a statistical analysis but an insistence about statistical synergy—a quality student response is more than just the sum of its parts.

One method of implementing holistic scoring is to decide in advance the number of categories into which student answers will be sorted. These may be labeled A, B, C, D, and F; distinguished, proficient, and novice; or simple numbers, 5, 4, 3, 2, and 1. The AP Statistics Scoring Guidelines for each free-response question on the exam have five categories, numerically defined on a 0 to 4 scale. Each category represents a level of quality in the student response. These levels of quality are defined in two dimensions: statistical knowledge and communication. The specific standards for each question are tied to a general template, which represents the descriptions of the quality levels as envisioned by the Development Committee. This general template is reproduced in the following table. Note that communication and statistical knowledge are given equal value.

9. Anthony J. Nitko, *Educational Assessment of Students*, 3rd ed. (Upper Saddle River, N.J.: Merrill, 2001), 194-95.

A Guide to Scoring Free-Response Statistics Questions:
The Category Descriptors

Score Descriptors	**Statistical Knowledge** (Identification of the important components of the problem and demonstration of the statistical concepts and techniques that result in a correct solution of the problem)	**Communication** (Explanation of what was done and why, along with a statement of conclusions drawn in context)
4 Complete	• Shows complete understanding of the problem's statistical components • Synthesizes a correct relationship among these components, perhaps with novelty and creativity • Uses appropriate and correctly executed statistical techniques • May have minor arithmetic errors, but answers are still reasonable	• Provides a clear, organized, and complete explanation, using correct terminology, of what was done and why • States appropriate assumptions and caveats • Uses diagrams or plots when appropriate to aid in describing the solution • States an appropriate and complete conclusion
3 Substantial	• Shows substantial understanding of the problem's statistical components • Synthesizes a relationship among these components, perhaps with minor gaps • Uses appropriate statistical techniques • May have arithmetic errors, but answers are still reasonable	• Provides a clear but not perfectly organized explanation, using correct terminology, of what was done and why, but explanation may be slightly incomplete • May miss necessary assumptions or caveats • Uses diagrams or plots when appropriate to aid in describing the solution • States a conclusion that follows from the analysis but may be somewhat incomplete
2 Developing	• Shows some understanding of the problem's statistical components • Shows little in the way of a relationship among these components • Uses some appropriate statistical techniques but misses or misuses others • May have arithmetic errors that result in unreasonable answers	• Provides some explanation of what was done, but explanation may be vague and difficult to interpret and terminology may be somewhat inappropriate • Uses diagrams in an incomplete or ineffective way, or diagrams may be missing • States a conclusion that is incomplete
1 Minimal	• Shows limited understanding of the problem's statistical components by failing to identify important components • Shows little ability to organize a solution and may use irrelevant information • Misuses or fails to use appropriate statistical techniques • Has arithmetic errors that result in unreasonable answers	• Provides minimal or unclear explanation of what was done or why it was done, and explanation may not match the presented solution • Fails to use diagrams or plots, or uses them incorrectly • States an incorrect conclusion or fails to state a conclusion
0	• Shows little to no understanding of statistical components	• Provides no explanation of a legitimate strategy

The Composite Score

Students' composite scores are determined by adding their scores for the two sections of the exam together. The maximum score is 100 points. All 40 multiple-choice questions in Section I are equally weighted, and the maximum possible score on this part is 50 points, or 50 percent of the composite score. A deduction is made for incorrect responses to discourage random guessing: one-quarter of the number of incorrect answers is subtracted from the number of correct answers. However, if a student can eliminate one or more of the choices as incorrect, it is advantageous to guess from among the remaining options. An answer that is left blank does not count against the student's score.

Each question in Section II is weighted so that free-response questions 1–5 each contribute 7.5 percent to the maximum possible composite exam score and question 6, referred to as the "investigative task," contributes 12.5 percent. The maximum possible score on Section II is 50 points, which is the remaining 50 percent of the composite score.

You are encouraged to read through all of the available Released Exams to see the AP Statistics Scoring Worksheet and the AP Grade Conversion Chart that are presented in each exam. This is also a good source of information about the development of AP Statistics Exams, their content and format, and scoring. Also included are the questions and scoring guidelines, examples of student responses, and commentaries on those responses. These commentaries help to explain how the score for a response was determined. In addition, free-response questions from the last several years for the operational and overseas exams (called Form B) can be accessed from the AP Statistics Exam Page. As with the Released Exams, here you will find the questions and scoring guidelines, examples of student responses, and scoring commentary. One method I started in my first year of teaching this course was to take the free-response questions, write up my solutions, and then score my work using the published guidelines. This gave me a better idea of how much detail was needed to score well on a question. I still find this to be a useful exercise.

AP Grades

The Chief Reader sets the four cut points that divide the composite scores into groups corresponding to the final AP grades of 1, 2, 3, 4, and 5. A variety of information is available to help the Chief Reader determine the score ranges into which exam grades should fall:

- Distributions of scores on each portion of the multiple-choice and free-response sections of the exam are provided, along with the totals for each section and the composite score total.
- With these tables and special statistical tables presenting grade distributions from previous years, the Chief Reader can compare the exam at hand to longitudinal results from other years.
- For each composite score, a table summarizes student performance on all sections of the exam.
- A subset of the multiple-choice questions is used for equating purposes. That is, a certain number of questions from an earlier exam are included in the current one, thereby allowing comparisons to be made between the scores of the earlier group of students and those of the current group.
- This information, along with other data, is used by the Chief Reader to establish AP grades that reflect the level of competence demanded by the AP Program and legitimately compare this year's AP grades with earlier years.
- Finally, on the basis of professional judgment regarding the quality of the performance represented by the achieved scores, the Chief Reader determines the students' final AP grades.

Many colleges consult their incoming students' AP grade reports when making placement and credit decisions. In general, an AP grade of 3 or higher indicates sufficient mastery of course content to allow placement in the succeeding college course and/or credit for and exemption from a college course comparable to the AP course.

Each college develops its own criteria for making AP credit decisions. Because the grade necessary for credit and the exams that will be accepted can vary from college to college and even from department to department within a particular institution, it is important for a student to clearly understand the policies for that educational institution. Sometimes the decision is based on whether the student's grade is 3, 4, or 5. Some colleges do not give AP credit at all, or only for selected courses. It is incumbent on students to ask questions about a university's AP policy when they apply to a school or visit a particular institution. One helpful source is on collegeboard.com. Students can click on *AP Credit Policy Info* on the AP student page, which will take them to a search tool where they can type in the name of an institution and be linked to information on its AP credit policy.

Preparing Your Students

Needless to say, the specific topics that you teach every day of the course prepare your students for success on the AP Statistics Exam. With a firm knowledge of the subjects included in the Topic Outline, they should be able to do well on this cumulative assessment. Yet time and again we find that even students who understand all the terms, correctly apply the formulas, and can provide good answers to the "stock" questions in elementary statistics still may not be as well prepared as possible for the open-ended questions. Why might this be?

Free-Response Question Skills and Strategies

Statistics is a discipline where communication is an essential skill. Consulting statisticians as well as investigators in various scientific fields must be able to formulate real research questions into appropriate statistical forms and then interpret the results of their statistical analysis for others. The evaluation of student responses on the free-response section of the AP Statistics Exam reflects the importance of clear communication and developing a habit of "statistical thinking" in addition to mathematical ability.

Practice Makes Perfect

Students need experience answering questions like those on the AP Exam. There are several ways to work these questions into your curriculum. The first is to make them part of your formal assessments. On the day prior to a unit test, I provide students with an "AP review," which consists of multiple-choice questions and occasionally a free-response question that deal with the concepts covered in that unit. Every test consists of a multiple-choice section, worth 60 percent, and a free-response section, worth 40 percent. This familiarizes students with the AP Exam format (which weights the two sections equally however), and it also requires them to develop critical thinking skills and time-management strategies. Be sure to include some multiple-choice questions that require students to critically apply statistical concepts rather than just demonstrate basic knowledge. Previous AP Exam free-response questions (found on AP Central) can also be used on unit tests.

In addition, many teachers use the published AP free-response questions as timed writing exercises in the classroom, allowing students approximately 12–15 minutes to complete each question. Students will be surprised at how short that time can be. Most will gain confidence and learn to manage their time better as the year progresses. Be sure to score all these questions, whether on tests or as practice assignments, using the guidelines posted on AP Central.

—Kathy Fritz, Plano West Senior High School,
Plano, Texas

AP Central contains scoring guidelines and commentaries on sample student responses for free-response questions from past AP Statistics Exams. This is an excellent place to become more familiar with the actual implementations of the guidelines for individual questions. However, there is a danger that the specificity of the guidelines for past questions can be misinterpreted. For example, one might be tempted to create overly narrow rules for students' statistical writing. Many of the free-response questions can be integrative in nature, as illustrated by the one featured in chapter 1 that includes data analysis as well as sampling elements. A particular hypothesis-testing question might ask students to comment on how the data were collected, and this would of course be reflected in the scoring guidelines. A cursory reading of one of the question-specific rubrics could lead one to conclude that for all hypothesis-testing questions a discussion of the sampling is required. This temptation must be resisted! Each rubric is written to reflect a particular question. For example, a specific element in the response to an inference question could be crucial, less than crucial, or even irrelevant in a different question.

Although it is not possible to completely codify guidelines or rules of thumb for approaching the free-response questions, it is possible to offer some general observations about common limitations and errors of omission and commission in student responses on past exams. Some benefits of experience from past AP Readings are provided below.

Defining Symbols and Interpreting Results

Students often fail to define symbols appropriately. For example, when writing a null hypothesis, a student should not just write $\mu = 75$ but should state what μ represents in the particular context. A clear and complete statement of a null hypothesis would be: "$\mu = 75$, where μ is the mean of the reading test scores for all students in this school." If students practice this policy throughout the course, they will have less trouble understanding that the null hypothesis is about the population, not about the sample. Similarly, under the time pressure of the exam, students may forget which Greek letter is appropriate to use and thus provide an incorrect symbol without explanation. Defining the meaning of a symbol will, in general, protect the student against ambiguity or the presumption of error. For example, defining d_a to be the population-mean effect of drug A may not be considered the standard way of proceeding, but it does eliminate ambiguity. Specifically, students should distinguish between population parameters and their estimates in words or with symbols. They should mention "the population mean" or "the sample mean," rather than simply referring to "the mean."

As a general rule, students should communicate in the commonly used symbols and format of statistics when writing their responses rather than using the symbols and format of their calculator (sometimes referred to as "calculator-speak"). For example, some calculators will perform a hypothesis test automatically and present the results on-screen differently from the commonly accepted statistical format, and students may then simply copy what they see on the calculator screen. This is seldom an appropriate form for communicating the process of hypothesis testing and should be avoided.

Students will sometimes write too much or too little. The best strategy is to (a) clearly answer the question asked and (b) stop. It frequently appears that students begin writing while still formulating their thoughts, perhaps under the impression that they are using their time efficiently. Also, some students seem to feel they must fill up the space allotted for the question. These two strategies have a common effect: producing irrelevant or possibly incorrect or contradictory communication at either the beginning or end of the response. A better approach is to read the question carefully and then respond to that question. Contradictory writing will always be regarded as incorrect—should two parallel solutions be offered, both will be read, but if one solution is of lower quality, the lesser score will be awarded.

Another widespread oversight is the failure to interpret the results of a statistical procedure. Many students assume that the statistical mechanics of the problem will carry the day. For example, they believe that writing down a confidence interval or stating "the null hypothesis is rejected" is sufficient and that the Reader will "know what was meant." Irrespective of what the student meant to write, the response will be evaluated on what was written. It is expected that beyond the mechanics, conclusions should be given in terms of the context of the question, whether it is an interpretation of the resulting confidence interval or an appropriate conclusion about the null hypothesis and how that conclusion was reached. If a question is presented in a context, the student must explicitly interpret the statistical results in that context.

Exploring Data

The graphical presentation of data is, of course, an excellent method of communicating about distributions of data and relations between variables. However, the effectiveness of graphs is compromised if the axes are not correctly labeled and scaled. In comparative displays, students frequently fail to label which group is associated with which display. Another common error is the use of different scales in a comparative setting. For example, the graphical clarity of comparative boxplots of the heights of males and females is destroyed if each boxplot has its own scale. Descriptions of distributions should as a matter of course address (in context) the center, spread, and shape, as well as unusual features such as outliers, gaps, and clusters. When comparing distributions, characteristics of each distribution should be mentioned explicitly. To say that distribution A is skewed to the right, for example, does not carry any implicit information that distribution B is not so skewed or that it may even be symmetric. In addition, comparative language must be used; for example, the median male adult height is *greater* than the median female adult height. This is quite different from simply listing the attributes of each distribution.

Planning Studies

Writing responses to questions about planning studies has historically been difficult for students. This is not surprising, as these questions tend to elicit the least formulaic responses and require a more exact use of statistical vocabulary. A student who, for example, struggles with hypothesis testing can demonstrate some knowledge by adhering to the stylistic form of the hypothesis-testing procedure. The "writing style" for discussion of methods of data collection and experimental design is almost blank verse by comparison. Some students are ambushed by this opportunity, writing long responses that may entirely fill the allotted space but that are, in effect, noncreditable answers. Possibly the best advice for responding to these questions is to know the vocabulary of sampling and experimental design and to write with precision using that vocabulary. In particular, when students are answering questions about experimental design, it is not uncommon for them to respond to questions that were not asked, leaving less time and space to respond effectively to the question that *was* asked. For example, if asked to identify a potential confounding variable in a particular scenario, it is not required nor is it necessarily helpful for students to provide a general definition of a confounding variable. If the intent of the question is to elicit such a definition, the wording will direct students to do so (see, for example, free-response question 3 on the 1999 exam).

Some students adopt a "shotgun strategy" and attempt to regurgitate everything they remember about confounding variables in hopes that they will stumble on something relevant to the question. With holistic grading, it is more likely that the lack of focus in their answers will count against them. Students are advised to be careful when using statistical terms such as *blocking, blinding, confounding,* and the like. These words need to be used precisely and in context or a deduction is likely. The same caution applies to students' use of vocabulary in sampling design versus experimental design.

Random Thoughts

Students sometimes demonstrate confusion about the differing purposes of random selection versus random assignment in statistical studies. Below is a summary that my students have found helpful in clarifying this important distinction.

Random selection is a method of obtaining a sample from a population of interest. Choosing a sample at random helps ensure that the individuals in the sample represent the population well. Random selection allows researchers to generalize sample results to the population as a whole.

Random assignment of subjects to treatment groups in an experiment is the researcher's best attempt to create groups that are as similar as possible before the treatments are administered. If the groups show significantly different responses, then researchers can attribute that difference to the treatments. In other words, random assignment helps researchers draw cause-and-effect conclusions from an experiment. Because the subjects in an experiment are usually not selected at random, this limits researchers' ability to generalize findings to a larger population of individuals. Both random selection and random assignment introduce chance variation into a statistical study. Statisticians use sampling distributions to quantify this chance variation when they construct confidence intervals or perform significance tests. The distinction becomes important in determining the scope of conclusions one can draw from the study.

The chart below (adapted from *The Statistical Sleuth* by Ramsey and Schafer) summarizes the different implications of random selection and random assignment in statistical studies.

		Were subjects randomly selected?	
		YES	**NO**
Were subjects randomly assigned?	**YES**	The researcher: —may infer cause and effect; *and* —may generalize findings to the population.	The researcher: —may infer cause and effect; *but* —may *not* generalize findings to the population.
	NO	The researcher: —may *not* infer cause and effect; *but* —may generalize findings to the population.	The researcher: —may *not* infer cause and effect; *and* —may *not* generalize findings to the population.

—Daren Starnes, The Lawrenceville School,
Lawrenceville, New Jersey

Probability

Probability questions are the most "mathlike" questions on the AP Statistics Exam, and students who know how to solve these problems should be relatively comfortable doing so. The difficulties that they may have in this area tend to be more organizational than conceptual. Here are some simple strategies students can use to improve their chances of doing well on probability questions.

- Students should state what formula they are using in their calculations and substitute values from the problem appropriately—at that point, not before, they should pick up their calculator. If students are using a particular probability distribution, they should identify the distribution with appropriate parameters. For example: "This is a binomial distribution with $n = 24$ and $p = 0.35$."
- If a problem requires a sequence of calculations, intermediate values should be shown. Generally, if a question has multiple dependent parts and a student makes an error on one of the early ones, the evaluation of successive parts will be based on whether the work presented is consistent with the work done earlier. That is, an error in part (a) will not automatically invalidate answers in parts (b), (c), and so on. Giving credit in the face of earlier errors depends on being able to trace the thread of reasoning through the problem.

- Take advantage of graphic representations of the problem and response. Displays of Venn diagrams and tree diagrams and shading of normal curves can effectively convey students' understanding of probability problems, as well as reduce ambiguity in the algebraic presentation of responses.
- Because probability questions are mathlike, it may be easy for students to forget that the question is presented in a context. They should not stop at just getting a numerical answer; the answer should also be embedded in the context of the problem as a complete sentence: for example, "the probability of a randomly selected fish weighing between 2.3 and 4.1 pounds is 0.2157," or as a probability statement such as "$P(2.3 < X < 4.1) = 0.2157$."
- Continue to caution against using "calculator-speak." Writing something like "binomcdf (12,0.4,7) = 0.9427" does not indicate to the Reader whether the student understands what the parameters for the distribution really are, nor does this count as "showing your work." A more appropriate response would be: "in a binomial distribution with $n = 12$ and $p = 0.4$, $P(x < 8) = 0.9427$." For examples on scoring such responses, see the scoring guidelines for question 3(b) on the 2007 AP Exam and question 3 on the 2006 exam. Emphasize the importance of effective communication.
- Credit is never given for just an answer. Some supporting work must be shown.
- Students should step back and make sure their answers are reasonable: for example, no probabilities greater than 1.

Inference

Answers to inference questions tend to be stylistic in nature, although presentations in textbooks are slightly different. Complete responses to inference questions in which the student uses hypothesis testing will generally require five components:

1. *The correct statement of a set of hypotheses.* Null and alternative hypotheses must be stated, correctly defining any notation used. H_0, μ, and α, for example, are standard symbolic notations and need not be defined. However, the use of the symbols should be specified: for example, "Let μ_A represent the population mean height of corn under treatment A." The symbols as presented on the formula sheet should be regarded as defined and meaningful; other notation should be defined before use. A common error is to specify the symbols μ_a and μ_b but then fail to link them to the particular populations under discussion.

2. *Identification of an appropriate test procedure.* The procedure and test statistic must be clearly specified. This should be in the usual statistical notation, avoiding the "calculator form" or listing the procedures for button pushing. The correct formula for the test statistic is usually the least ambiguous identification of a procedure, although a statement such as "two-sample *t* test for independent means" is also acceptable.

3. *Identifying and checking the validity of appropriate assumptions.* An important part of using inferential procedures is recognizing that all statistical models depend on assumptions that underlie and justify the procedures used in that model. If these assumptions are violated, then the procedures may produce inappropriate conclusions. The problem is that these assumptions are typically about populations and models and cannot be directly verified. Many times we know little about the population, so it is not reasonable to "check" whether such assumptions are true or not. Some assumptions, in fact, are unverifiable, and we just have to decide whether or not we believe they are true. If we have data, we can often decide if an *assumption* about the population or model is reasonable by checking a related *condition* based on the sample data to see if it is plausible to believe that the assumption about the population is true. For example, one of the assumptions for inference

procedures about a single mean is that the data were drawn from a normal population. Since we typically do not have access to the population data, we have no way to verify this assumption. Instead, we look for signs that this assumption is not reasonable. So the condition we check is whether there is evidence to convince us that it is unreasonable to believe the sample data came from a normal population. With a small data set, we have to worry about outliers and skewness, and we commonly check this condition using graphs: constructing a histogram, dotplot, or probability plot of the data. If there are no outliers or other indications of skewness, then the *t*-procedure can be justified. For complete communication, these graphs need to be included in the student response. Simply stating that there are "no outliers," without including graphical evidence, is not sufficient.

With the *t*-procedures, even if we have reason to believe the population is not normal, the procedure is still considered valid if the sample size is large, as then the sampling distribution of the sample mean is approximately normal. Notice this large sample size in no way implies that the original population was normal. How large the sample size needs to be varies by textbook (30 or 40 are common cut-offs) and also by the level of skewness in the data. Students should also exercise care when using "is normal" and "is approximately normal." Rarely are we working with exactly normal distributions, so the qualifier "approximately" is important.

Similarly with categorical data, different texts will counsel slightly different requirements, and no specific requirement is enforced by the question's scoring guidelines, though a few are commonly accepted in the statistical community. For example, requirements for using the large-sample *z* test for a single population proportion are usually stated in the format, $np \geq k,\ n(1-p) \geq k$, but the actual value for *k* will differ depending on the text. What is important is that the student knows there are assumptions that underpin inferential procedures and recognizes which are appropriate conditions for the selected procedure and explicitly checks them, including appropriate justification. A common omission is the actual checking of the condition by substituting values for $n,\ p,\ k$ and evaluating whether the conditions are met—for example, many students will write $np > 10$ (or use some other value for *k*) and then put a check mark next to it thinking that they have "checked" the assumption or condition. In all cases, simply stating the conditions without checking them explicitly is not sufficient for a complete response.

An excellent aid to understanding the difference between assumptions and conditions is Dave Bock's article, "Is That an Assumption or a Condition?" It can be found on the AP Statistics Course Home Page by scrolling down to *Teaching Resource Materials* and then to *Statistical Inference*. As Dave suggests, start making this distinction early in the year.

4. *The correct mechanics*. This is usually a matter of showing intermediate steps in an organized manner. The correct values of the test statistic, the level of significance, and the *P*-value, appropriately identified in the body of the work, are essential.

5. *Correct conclusions stated in the context of the problem*. Test statistics must be used to arrive at the correct conclusion, either via the *P*-value approach or a rejection region approach. Linkage between the conclusion and test result should be stated clearly; for example: "Because the *P*-value is less than .05, the null hypothesis is rejected." Of critical importance is the conclusion stated in the context of the problem, consistent with the defined hypotheses. That is, a rejection of a null hypothesis should then be correctly interpreted as, say, providing evidence of a difference in the population parameters.

If confidence intervals are used for making inferences about population parameters, the considerations above still apply. One particular omission that seems to occur when confidence intervals are used is the check of conditions for the procedure. Both confidence intervals and hypothesis testing are based on the sampling distribution, and both procedures require checks of the conditions! If a confidence interval approach is used, a correct confidence interval statement is also required. Students frequently err by making an incorrect probability statement, or indicate that they have confidence that a sample value rather than a population value is in a certain interval.

Rounding Answers

Remind your students that it is best not to round numbers at intermediate steps in a calculation. Answers should be rounded only at the end and then not too much. For example, a z-score should be rounded to two decimal places in order to use the table, but each step in the calculation should not be rounded at all, or the final z-score may be quite different from what it would have been otherwise.

A very general rule of thumb is that most answers can be rounded to two decimal places. Yet even then, an exception is made for calculating probabilities, which should be kept to four decimal places, thus matching the tables students will use during the exam.

Responding to Common Prompts

As students work through the free-response questions, they will be asked to respond in a variety of ways. Some questions can be quite straightforward, such as "find the probability of. . . ." Others are more implicit. It is suggested that you use some of the typical examples that follow or similar prompts and instructions throughout the year as you make writing an integral part of your course.

- Students may be asked to make a choice between two alternatives. Not only should they make a decision and marshal their arguments for it; they must also explain why this choice is better by pointing to the weaknesses of the alternative approach.
- When asked to compare two distributions, students are not likely to receive credit if they just make a list of the attributes. Comparative words—*greater than, less than, about the same*—need to be used when comparing center and spread; for example: "There is less variability in the distribution of the weights of female bears than in the distribution of the weights of male bears."
- Directions to justify or explain the answer mean exactly that. These usually accompany questions that require a choice between alternatives, as mentioned above, or the answer to a "yes or no" question. Students are expected to explain *why* they chose that answer, using a statistical justification. Justifying an answer can also mean showing enough work so that the Reader can follow the logic. **Answers without work will not receive credit, even if the question does not explicitly ask students to justify or explain.** Students are expected to read the instructions at the beginning of the free-response questions; they will not be reminded along the way that they need to show their work and justify their answers.
- "Using your answer in part (a) …" questions must have some reference to the work done in that part. Students must cite evidence that includes the calculation from part (a). If there is an error in the calculation of the first part, and the incorrect value (if it is plausible for the problem) is used correctly in subsequent calculations, students will only lose credit for the first mistake.
- If instructions in part (c) say "using only your answers in parts (a) and (b)," this usually means that no further calculations are necessary to answer this part. Students should explicitly reference and synthesize previous work in answering part (c). Those who go off in a new direction are wasting precious time and might actually incur a deduction.

- Instructions such as "include appropriate statistical evidence" may mean that students should conduct some inference procedure or calculate a probability or some other statistical analysis as part of the justification for their answer.
- All work should be "in the context of the problem." If students are asked to interpret a value, relationship, or concept, such as slope, correlation, a scatterplot, or confounding, they should not use generic terminology. For example: "There is a strong negative linear relationship between the age of a driver and the distance at which highway exit signs can be clearly read by the driver."

Prove Yourself

"Justify your answer." These words commonly appear on AP Statistics Exam free-response questions, but students are sometimes unsure about exactly what this phrase is asking them to do. For many of these questions the actual answer is very short, sometimes consisting of a single sentence. But along with a correct answer to the question, students must also convince the Exam Reader that they have answered as they have for a sound, statistically correct reason. My advice to students is to always think of their answer in three parts: first, make a clear statement of the answer. Next, state the statistical concept that supports their answer. Then, finally, show how the stated concept supports the answer in the context of this question. This final link demonstrates that the student can accurately and confidently connect the details of a particular problem to his or her statistical knowledge.

—Peter Flanagan-Hyde, Phoenix Country Day School, Phoenix, Arizona

The Investigative Task

Finally, it is important to understand the philosophy and intent of question 6—the investigative task. This is always the last question on the free-response portion of the AP Statistics Exam. For many students, and some teachers, it can be the most vexing question to approach and embrace.

Covering all of the course content does not mean that you or your students have encountered a problem exactly like question 6 (in fact, it is intended to be unfamiliar to students). The purpose of the question is to take students beyond the topics taught in the course; yet the question must be accessible based on the *concepts* that they have learned over the year. Several parts of the investigative task may look reasonably familiar to students and assess standard elements of the curriculum. This might include a test of significance, some exploratory data analysis or probability, or some element of sampling and design. The investigative part is usually the last part and likely will present students with something they have never seen before—a situation that they will have to think about carefully and creatively, and whose correct analysis will involve applying familiar concepts and skills in a new way. The important question is: do students really understand the concepts sufficiently to use sound statistical thinking when confronted by a new situation?

If you look through past investigative tasks, you will see all sorts of things you did not "cover," such as a test for variance, one-sided confidence intervals, an elliptical graph based on some summary statistics and a correlation, or the construction of an interaction graph to be used to draw some conclusions. The idea is to present something that is *not* covered in the standard curriculum, except insofar as the curriculum includes imparting general skills that are applicable to new situations. Some of your students will rise to the challenge and shine, while others will make a good attempt at the investigation but fall somewhat short. Others may not be able to successfully answer the investigative part of the question but will do a good job on the first part that evaluates standard curricular concepts. Some teachers advise their students not to wait until the end of the 90-minute period for the free-response section, when they will be most tired, to attempt to answer question 6.

How do you prepare students for the investigative task? We teachers personally have probably had little preparation for this sort of question, either in our own education or in many of the textbooks we use. Surveying past investigative tasks can be instructive as to what was "off the board" curriculum-wise that year, and it can help students understand what is "investigative" about a problem and how they can approach it based on what they do know; however, looking at past investigations will not tell us what might happen on future exams. Some teachers have tried writing their own investigations; suggestions for such activities have occasionally been posted on the AP Statistics Electronic Discussion Group. It is worth noting that in recent years students have been doing better on the investigative task. Readers are not seeing as many blank papers, because students are being encouraged by their teachers to think creatively and to do something "reasonable" on these challenging problems.

The important thing for students to remember is not to panic. What they are being asked to do is step outside their comfort zone for a moment and to think statistically, going beyond just knowledge of formulas and procedures. Such a request appears as one part of one question on a three-hour exam.

Year-End Review

The best way to adequately prepare students for the AP Exam is to deliver a solid, well-grounded course throughout the school year. By this reasoning, exam preparation begins on the first day, but there is still the need to allow adequate time for exam review and preparation. For many teachers this is somewhere between two and four weeks. There are many strategies for conducting a successful review. Some of these have been illustrated in the sample syllabi in chapter 3. Others are listed below.

- Use one of the available review books. A number of these are listed in chapter 5, Resources for Teachers.
- If you do not have the AP Released Exams in your possession, you might be able to acquire them from experienced teachers. They can also be purchased online at store.collegeboard.com.
- Give your students the Statistics Practice Exam available on AP Central to teachers whose syllabi have met the course audit requirements.
- Work with your school's AP Coordinator to ensure that students are aware of all the rules and procedures associated with the exam so that extraneous factors will not add to their stress level.
- Some schools hold a "mock exam" on a Saturday morning sometime in April, using one of the Released Exams. This event allows students to actually experience the testing conditions they will experience on exam day and helps them develop a better sense of how to manage their time so as to get though both sections of the exam, especially the free-response section. Some schools do this individually if traveling is problematic, whereas others conduct it in cooperation with other high schools in their area. (See the Review for the AP Exam section of Jeane Swaynos's syllabus for her description of the mock exam at Seminole High School.) All teachers agree beforehand not to use the problems from the proposed "mock" exam during the rest of the year. If you have a local AP Statistics support group, it could serve as the organizational vehicle to disseminate information and get the ball rolling.
- Share and discuss sample student responses and scoring guidelines when you do past AP Exam questions in class (all are available on AP Central). Additional student responses can be obtained at one- and two-day or weeklong College Board workshops. Let your students grade their classmates' work, if your school has no policy prohibiting this. If such a policy exists, then have them grade their own work. I have successfully used the following approach: I choose an AP problem based on the current or a past topic and give it as an in-class, timed (12 to 15 minutes) writing assignment. Once students have completed the assignment, I review the scoring guidelines with them. Then the

class practices evaluating a set of sample student responses drawn from workshops and AP Central. They score several papers, and I discuss the score that the paper actually received and why. Finally, they score their own response to the problem given at the beginning of the period. I then pick up the papers and recheck their judgments.

- Incorporate old AP Exam questions either on tests or as independent problem sets. Quite a few teachers include an AP free-response question on each test throughout the year. Starting early in the year, I also give students one or two free-response problems each week, which I call an “AP set” (see chapter 3). Students have five or six days to work on this set and then turn it in. They may use their notes and textbook, but they must work alone. I then score their work using the published guidelines (which I share with them), return it, and discuss the questions. It is important for students to understand precisely how the AP Exam is scored and what is valued. There is no more educational moment than the revelation that computations alone do not get them very far without accompanying explanations, interpretations, and justifications. The problem-set strategy has been particularly effective for me. I direct you to several of the syllabi in chapter 3, where the authors—among them Josh Tabor, Dora Daniluk, and Michael Allwood—discuss some of their favorite AP problems.
- Build cumulative review exercises into your homework assignments. Most statistics textbooks do not use a spiral approach nor do they contain much in the way of cumulative reviews. Because the exam is not organized by topic, students need to have some practice in applying and integrating statistical procedures that were studied early in the course and have not been used for a while. You can also try to adopt a “statistical process” approach to all problems from the beginning of the course, thinking about issues of design, analysis, and scope of conclusions every time.
- Go to the *Exam Tips: Statistics* link on the AP Statistics Course Home Page. Here you will find observations from the Chief Reader and exam tips for teachers and students.
- Share the instructions for the exam with students. For example, some AP Exams are to be done in pen, whereas others are strictly pencil. The AP Statistics Exam can be written in pen or pencil. Review with students the acceptable use policies concerning calculator enhancements. These can be found on the AP Statistics Course Home Page. A complete set of exam instructions can be found in the Released Exams or obtained from your school’s AP Coordinator.

The tone of the year-end reviews should be positive and upbeat. Students are in the home stretch and may begin to wane in their enthusiasm. A pep talk may be helpful. I try to convey my belief that they can do well on the AP Exam, but that they need to work hard and stay focused through the review to gain the best advantage they can. After all, you and your students are in this together. None of us know what questions will be on the exam. A brief perusal of the experimental design questions, for example, shows that each one has been quite different and that using past problems to predict future questions is probably not useful. The common goal for everyone is a job well done. I am their cheerleader in this. I also remind them that they should be well rested. Despite the claim of many students that “they work well under pressure,” last minute, late-night cramming can be highly counterproductive.

My second trimester exam in February is a three-hour “mock” AP Exam. There are 40 multiple-choice questions, drawn from the 1997 exam, the multiple-choice questions in the several editions of the Course Description, and some of my own, along with six free-response questions from past AP Exams. Because students have already “done” the three-hour exam, I do not feel the necessity of repeating the experience during the intense review time at the end of the year.

The first week of review is a category-by-category synopsis—one day each on experimental design, exploratory data analysis, probability and random variables, regression, and sampling distributions.

Assignments during this week include some of the released free-response problems I haven't yet used, several investigative tasks, and several sets of multiple-choice questions I have assembled over the years. On Friday of this review week, the students are given the 2002 Released Exam to complete on their own time. I ask them to set aside two blocks of 90 minutes over the next four days to accomplish this, using only their formula sheets and tables from the exam, plus their calculators. This extended time period allows students to schedule the exam around their other academic and family obligations. Once they turn it in, I grade it, and we go over it using the scoring guidelines for the free-response questions. We fill in any remaining review time with free-response problems remaining from past exams.

After the Exam

Every year there are suggestions on the AP Statistics Electronic Discussion Group concerning what to do with the gap of time that some school districts have between the administration of the AP Exam and the end of the school year. This may be an opportune time for an independent project that lets students explore an area of interest to them and display what they have learned during the year. Because students sometimes have difficulty choosing a project topic, some sources and suggestions are included in the following list.

- Each syllabus in chapter 3 has some suggestions for student activities, including projects. For example, both Josh Tabor and Jared Derksen describe projects exploring the concept of bias.
- There are many suggestions listed in the article "After the Exam: Activities and Projects," listed under *Teacher Resource Materials* on the AP Statistics Course Home Page.
- You can also find quite a few examples of past projects on several of the experienced teacher Web sites (an excellent source is Al Coons, www.bbn-school.org/us/math/ap_stats).

Below are some specific projects that students might enjoy researching:

- Does bread really fall butter side down?
- Which type of cookie (chocolate chip, sugar, or oatmeal raisin) do students prefer?
- Are certain golf balls better than others for putting?

A project might not suit everyone's needs, so here are several other suggestions:

- Some teachers show one of the films or videos listed under "Multimedia Resources" in chapter 5. These teachers have developed several handouts and worksheets that can be found by searching the discussion archives.
- Chapter 5 also contains a list of suggested popular books that you might find useful. These include several titles by John Allen Paulos, *Damned Lies and Statistics* by Joel Best, *Freakonomics* by Steven Levitt and Stephen Dubner, and *Polling Matters* by Frank Newport.
- Teach a few additional topics. Chapters on multiple regression and ANOVA are frequently included in textbooks and are not very hard to introduce to students who have completed the AP Statistics Topic Outline.

School's (Almost) Out for Summer

Each year after the AP Statistics Exam, I have students complete a project of their choice. The goal is to review and use several big ideas from the field of statistics in a way that is interesting and fun. Before they can begin, each project must be approved. The project must involve collecting and analyzing data, displaying data, inference, and presenting the findings to the class. I consult and arrange administrative approval if necessary (surveys at lunch, for example). We take two or three days to present projects to the class. Students may choose to work individually or in groups of two or three.

Students in the past have analyzed the mean weights of different types of Hershey's Kisses,® analyzed our state graduation exam data, compared NCAA basketball conferences by creating a rating formula and using data available on the Internet, surveyed students about various issues, compared accuracy of generic versus brand-name paint balls (by shooting at a target on a barn—generic were better), compared distance and accuracy of dimpleless versus regular golf balls, and tested whether eating a mint affects the time required to solve a simple puzzle (as their elementary school teacher once claimed). Some of the best learning has occurred from projects that did not turn out as students expected!

—Dave Ferris, Noblesville High School,
Noblesville, Indiana

Rules for Discussing the Exam Questions with Students

Teachers should take the opportunity to talk about each year's most recent AP Exam with their students, within the established boundaries. Any discussion should start with a reminder to students about their agreement not to disclose any of the actual multiple-choice questions that appeared on their exam. The reason for maintaining the security of the 40 multiple-choice questions is the inclusion of the equating questions from a past exam. If these equating questions were disclosed, they could not be used in the future, and year-to-year comparisons would be compromised.

The free-response questions are posted on AP Central 48 hours after the administration of the exam. Until that time, you cannot discuss them with students, but you may fully do so afterward. If some of your students take the alternate exam during the late-testing period, you are never allowed to discuss those free-response questions, because the alternate exam is not released.

My concern, first and foremost, is to know if there were any topics for which my students felt unprepared or felt especially well prepared. The focus needs to be on general questions. You may certainly ask students how well the course prepared them to answer questions on regression or probability, for example, without getting into the specifics of actual exam questions.

Feedback from the AP Exam

AP Grade Reports

AP grades are reported to students, their schools, and their designated colleges in July. Each school automatically receives an AP Grade Report for each student, a cumulative roster of all students, rosters of all students by exam, an AP Scholar roster for any qualifying students, and an *AP Instructional Planning Report*. (Note: Data for students testing late with an alternate form of the exam are not included in this report.) For a fee, schools may also request their students' free-response booklets.

Using the AP Instructional Planning Report

Schools receive the *AP Instructional Planning Report* for each of their AP classes in September. The report compares your students' performance on specific topics in the AP Exam to the performance of students worldwide on those same topics, helping you target areas for increased attention and focus in the curriculum. To get the most out of the report, please read the interpretive information on the document. It explains how the data, when used correctly, can provide valuable information for instructional and curricular assessment as well as for planning and development. Contact your school's AP Coordinator for this report.

Many factors can influence exam results. Differences in performance between your students and the worldwide group may be the result of any number of factors. Some of these might be different instructional methods, differences in emphasis or preparation on particular parts of the examination, differences in curriculum during the pre-AP years, or differences in student background and preparation in comparison with the global group.

Using the *AP Instructional Planning Report* you can compare your students' performance to the global group on the multiple-choice and free-response sections of the exam. Scores are broken down into four categories: lowest, second, third, and highest quartiles. The quartiles do *not* correspond to the final AP grades of 1, 2, 3, 4, or 5. The report also compares the global group to your students' results for the four content areas of the multiple-choice questions—exploring data, probability and simulation, statistical inference, and sampling and experimentation. For example, if your students seem to be scoring in the lowest fourth on the sampling and experimental design multiple-choice questions, it may indicate a content area to which you should devote more attention next year. Or it may mean that your students just need more practice completing multiple-choice questions about sampling and design.

Each of the six free-response questions uses the same performance categories of quartiles. Examine each question carefully, looking for similarities and differences between your students' performance and that of the global group. Is the mean performance for your students the same as the global mean? How difficult did your students find the question (or group of questions) compared with the global group? If your group is below the global population only on free-response questions, for example, writing and organizational skills may need to be emphasized in the future. The *AP Instructional Planning Report* is meant to provide valuable feedback in order to help you assess the progress of your course and point to areas of success as well as areas that may need more attention. Be sure to take advantage of it.

Chapter 5
Resources for Teachers

Useful Information Sources

The following resources will be helpful to both new and experienced teachers of AP Statistics. Some of these sources contain information that may be at a more advanced level than the AP Statistics course, and they are included to assist teachers who wish to extend their knowledge in specific or general statistical areas. Others are relevant to the teaching of statistics in general, or to particular topics in the AP Statistics curriculum. Because such a large amount of material is available, you should approach your acquisition of resources in stages. As you expand your collection of resources, you can begin to add textbook support materials, news articles, magazines, journals, newsletters, movies, and other multimedia items.

The first thing you will want to choose is the textbook that best suits the needs of your students. Next, essential information about the AP Exam can be found in the Course Description, in AP Statistics Released Exams, and on AP Central. The Course Description, discussed in chapter 1, is available in downloadable format on AP Central. In this book you will find about a dozen multiple-choice questions indicative of those that appear on the AP Exam. Note that they are not computational in nature and not calculator-driven. If you have an older version of the Course Description (before 2004) or happen to know someone who does, the multiple-choice set in that book is different. You might try to get your hands on this older set in order to have more multiple-choice questions available for your use.

Printed versions of complete AP Exams are usually released every four or five years. The 2007 and 2002 AP Statistics Exams are currently available at store.collegeboard.com. Each Released Exam contains both the multiple-choice and free-response questions and solutions, along with scoring guidelines and commentary on the scoring. The Released Exam is where you can read about how the exam is developed and scored, how Readers are trained to score the free-response questions, the instructions that students will be given on the day of the actual exam, and the scoring worksheet and comments on how the actual AP grade is determined.

Free-response questions and scoring guidelines from past years are available at no cost on the AP Statistics Exam Page on AP Central. This includes free-response questions from recent Form B exams (the overseas exam). In addition, there are three actual student responses for each question, along with commentary on the scoring of each response. Be sure to also avail yourself of the AP Statistics Practice Exam (which includes both multiple-choice and free-response questions) that is available as a free download if your syllabus has been approved in the AP Course Audit process.

The following compilation was current as of the writing of this publication; however, the reader should be aware that new books and teaching aids are being introduced all the time. A continuing source for learning about the latest resources is the AP Central Web site, which is described in detail in chapter 2. Some of the resources included here are also listed at AP Central, with descriptions and evaluations by statisticians and teachers of AP Statistics. (Note: This list of resources is not meant as an endorsement by the College Board or the AP Statistics Development Committee of any particular publication or author.)

Print Resources

Basic Textbooks

There is no one textbook that will be the best for all students in all situations. The information presented here is meant to provide you with some of the basics of each text. Carefully consider the merits of each book as they apply to your students. You may want to obtain sample copies (available from the publishers' Web sites) and look through them, comparing the style of presentation, examples provided in the body of the text, and practice exercises. Are the problems interesting, varied, and of sufficient number to provide several assignments as well as review? One way you might approach this is to choose a topic, such as one-sample confidence intervals, and read through the appropriate chapter in each text you are considering. Does the style of writing and presentation fit with your style of teaching and how you think about statistics? How accessible are the writing and problems to your students? Some of the books include calculator instructions and keystrokes in the body of the examples and reading, whereas others list them at the end of the chapter or in separate sections within the chapter. Even though it is essential that students have intimate knowledge of the statistical capabilities of the calculator, you need to consider when that instruction will occur.

In addition, most of these texts have companion Web sites that contain demonstration applets for student and teacher use, test banks, solutions manuals, an instructor's guide, and/or supplemental review materials. You will want to examine these as well. Some are accompanied by a CD-ROM of data sets from the textbook that are easily downloadable in various formats to statistical software. Statistical software can also be bundled with several of the texts for an additional charge. The best place to gather information about this support material is to go to the publisher's Web site. Although you may be using one publisher's textbook you may, in fact, prefer to use the AP review material from another. Look at the various guides, or ask someone who is currently teaching the course for advice. With that in mind, the following list includes those texts that are most often cited, discussed, and recommended on the AP Statistics Electronic Discussion Group (EDG). They are in alphabetical order by lead author.

- Bock, David E., Paul F. Velleman, and Richard D. De Veaux. *Stats: Modeling the World*. 2nd ed. Boston: Pearson/Addison-Wesley, 2007.

  The style of this textbook is a bit more informal and colloquial than several of the other texts. There are lots of exercises to choose from, and in some cases the same data are used in more than one context. For example, an exercise that appears in the chapter on probability may also be used in the inference chapter on comparing counts (chi-square). The teacher's edition comes bundled with a CD containing *ActivStats*. An AP Exam review guide with four mock exams is also available (see the Exam Review Guides section later in this chapter).

- Moore, David S., and George P. McCabe. *Introduction to the Practice of Statistics*. 5th ed. New York: W. H. Freeman, 2006.

  This text can be somewhat daunting. Some of the sections are quite long, and breaking them up into manageable chunks takes some experience and a good sense of organization. On the other hand, it is very well written, and a wealth of support material is available, including a CD containing data sets and practice problems. The fifth edition has been updated with lots of new exercises, and sample output screens have been added for *Minitab, SPSS, JMP,* T1-83/84, and *Crunchit!* This text can be a bit overwhelming for a first-year teacher of the course, but if you are reasonably confident of your statistics background, it can be a very effective book. Because it is a college text, it lacks some of the "flavor" of AP-type problems, which you will have to find through other sources.

- Peck, Roxy, Chris Olsen, and Jay Devore. *Introduction to Statistics and Data Analysis*. 3rd ed. Belmont, Calif.: Thomson Brooks/Cole, 2008.

  The authors are well known and have been highly involved with the AP Statistics program. Roxy Peck is a former Chief Reader for the AP Statistics Exam, and Chris Olsen was on the original Development Committee and is a very frequent contributor to the EDG. This was one of the first texts to be written specifically for AP Statistics. A large resource binder and a complete test bank are available.

- Watkins, Ann E., Richard L. Scheaffer, and George W. Cobb. *Statistics in Action: Understanding a World of Data*. Emeryville, Calif.: Key Curriculum Press, 2004.

  The philosophy of the authors, who are known nationally in the field of statistics education, is that statistical work is much more active than it was a generation ago. Gathering data, exploring data, and making inferences from data should be a hands-on experience. This text is an activity-based approach that will be familiar to those who have seen *Activity-Based Statistics* (see the Supplementary Textbooks section below).

- Yates, Daniel S., David S. Moore, and Daren S. Starnes. *The Practice of Statistics: TI 83/84/89 Graphing Calculator Enhanced*. 3rd ed. New York: W. H. Freeman, 2007.

  This text is an updated version of the 1999 first edition by Yates, Moore, and McCabe (one of the first to be geared toward a high school audience) and the 2003 second edition by Yates, Moore, and Starnes. As with the other texts, the companion Web site contains plenty of fine support material, applets, and online demonstrations. Ancillary resources in the *Golden Resource Binder* are considered outstanding by many teachers. The third edition includes a new AP Exam prep guide (see the Exam Review Guides section below).

Other textbooks will most certainly be published in the future that will align with the AP Statistics curriculum. I urge you to regularly visit the AP Statistics Course Home Page at AP Central. There you will find more than 150 reviews of teaching resources, including current and newly published textbooks, all written by experienced statistics instructors. There are lots of textbooks available, but many were not written with this course in mind. Please consider your choices carefully. A good textbook is an essential element for a successful course and for making your life a bit easier.

Supplementary Textbooks

In addition to the primary textbook that you select for your course, there are many other fine textbooks on the market that present challenging statistical concepts particularly well, for both your understanding and that of your students. Some of these are listed below. Commentaries are included for selected books in this list.

Chance, Beth L., and Allan J. Rossman. *Investigating Statistical Concepts, Applications, and Methods*. Pacific Grove, Calif: Duxbury Press, 2005.

Chatterjee, Samprit, Mark S. Handcock, and Jeffrey S. Simonoff. *A Casebook for a First Course in Statistics and Data Analysis*. New York: Wiley, 1995.

Freedman, David, Robert Pisani, and Roger Purves. *Statistics*. 4th ed. New York: W. W. Norton, 2007. This is a text that I usually turn to first when I need to check some concept.

Hand, D. J. et al., eds. *A Handbook of Small Data Sets*. New York: Chapman and Hall, 1994.

McClave, James T., and Terry Sincich. *Statistics*. 11th ed. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2007.

Moore, David S. *The Basic Practice of Statistics*. 4th ed. New York: W. H. Freeman, 2007.

Moore, David S., and William I. Notz. *Statistics: Concepts and Controversies*. 6th ed. New York: W. H. Freeman, 2006. This is an excellent source of ideas for free-response questions and writing exercises.

Peck, Roxy et al. *Statistics: A Guide to the Unknown*. 4th ed. Belmont, Calif.: Thomson Brooks/Cole, 2006. A compendium of well-written essays and case studies on applications of statistics from the fields of business and industry, public policy and social science, biology and medicine, and others. This is an excellent source of supplemental readings to enhance any introductory statistics course.

Ramsey, Fred L, and Daniel W. Schafer. *The Statistical Sleuth: A Course in Methods of Data Analysis*. 2nd ed. Pacific Grove, Calif.: Thomson/Duxbury, 2002. It would be difficult to find a book that matches the philosophy of the AP Statistics course as well as this one. Although it could not reasonably be used as a textbook for the AP course, it is an ideal resource for teachers. It is organized around case studies, and the data are very real and interesting.

Rossman, Allan J., and Beth L. Chance. *Workshop Statistics: Discovery with Data*. 2nd ed. Emeryville, Calif.: Key College Publishing, 2001. The third edition will be published in 2008. The *Workshop Statistics* books contain an excellent series of student-centered, hands-on activities that are well written and easy to follow. Students can explore statistical principles, discover statistical concepts, and apply the various statistical techniques to interesting data sets. Many teachers use this as a supplemental text to other written sources, because some AP topics are not included in this book. Technology-specific versions are also available: see the next three listings.

Rossman, Allan J., and Beth L. Chance. *Workshop Statistics: Discovery with Data and Minitab*. 2nd ed. Emeryville, Calif.: Key College Publishing, 2001.

Rossman, Allan J., Beth L. Chance, and Robin H. Lock. *Workshop Statistics: Discovery with Data and Fathom*. Emeryville, Calif.: Key College Publishing, 2001.

Rossman, Allan J., Beth L. Chance, and J. Barr von Oehsen. *Workshop Statistics: Discovery with Data and the Graphing Calculator*. 2nd ed. Emeryville, Calif.: Key College Publishing, 2002.

Salsburg, David. *The Lady Tasting Tea: How Statistics Revolutionized Science in the Twentieth Century*. New York: W. H. Freeman, 2001. This book is a wonderful supplement for those interested in the history of statistics. Although not an easy read, I would recommend it as independent reading for any interested student of statistics and as terrific background reading for teachers.

Scheaffer, Richard L., William Mendenhall III, and R. Lyman Ott. *Elementary Survey Sampling*. 6th ed. Belmont, Calif.: Thomson Brooks/Cole, 2006.

Scheaffer, Richard L., Ann E. Watkins, Jeffrey A. Witmer, and Mrudulla Gnanadesikan. Revised by Tim Erickson. *Activity-Based Statistics*. 2nd ed. Emeryville, Calif.: Key College Publishing, 2004.

Siegel, Andrew F., and Charles J. Morgan. *Statistics and Data Analysis: An Introduction*. 2nd ed. New York: Wiley, 1996.

Tufte, Edward R. *The Visual Display of Quantitative Information*. 2nd ed. Cheshire, Conn.: Graphics Press, 2001.

Utts, Jessica M. *Seeing Through Statistics*. 3rd ed. Belmont, Calif.: Thomson Brooks/Cole, 2005. Each chapter starts with several interesting and useful "thought questions." These make nice writing exercises.

Utts, Jessica M., and Robert F. Heckard. *Mind on Statistics*. 3rd ed. Belmont, Calif.: Thomson Brooks/Cole, 2007. One of my favorite books, this contains lots of nice problems and data sets.

Exam Review Guides

Several exam preparation books are available for AP Statistics. Many teachers use these for end-of-year review. Others have used them for semester and trimester review as well. Some of the titles below are available only from the publishing company, whereas others can be purchased in your local bookstore.

Bohan, James. *AP Statistics: Preparing for the AP Examination*. New York: AMSCO School Publications, 2000. (Order at www.amscopub.com.)

Carroll, Anne M., Ruth E. Carver, Susan A. Peters, and Janice D. Ricks. *Preparing for the Statistics AP Exam with "Stats: Modeling the World," 2nd ed.* AP Test Prep series. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2007. (Order from the company.)

Hinders, Duane. *5 Steps to a 5: AP Statistics*. New York: McGraw-Hill, 2004. (Available in bookstores.)

Legacy, Michael. *Prep for the AP Exam Guide for Yates, Moore, and Starnes's "The Practice of Statistics," 3rd ed.* New York: W. H. Freeman, 2008. (Order from the company.)

Levine-Wissing, Robin, and David W. Thiel. *The Best Test Preparation for the AP Statistics Exam*. Piscataway, N.J.: Research and Education Association, 2006. (Available in bookstores.)

Sternstein, Martin. *Barron's AP Statistics: How to Prepare for the Advanced Placement Exam*. 3rd ed. Hauppauge, N.Y.: Barron's Educational Series, 2004. (Available in bookstores.)

Newspapers and Magazines

Statistics, in one form or another, can always be found in the news. This is one of the reasons that this course is particularly relevant for students! Make it a habit to check your local newspaper for current studies or news articles that have a statistical bent. For example, a good source for graphs is *USA Today*. The science section of the *New York Times*, or *Science News*, which your science department may receive, provide lots of useful material. You might want to pass out the articles and have students discuss the statistical aspects of the stories. Some teachers distribute a news report, then have students go online to the original journal of publication, download the study, and compare the actual study with what the news article reported. Did the reporter get it right? I have also found pertinent articles in *Time, Newsweek, U.S. News and World Report*, and the *Economist*.

Collect articles and keep a file! You may use an article or clipping in class, or it may be the basis for a test question.

Popular Reading

Below is a list of suggested readings for both students and teachers, gleaned from a variety of sources and teachers' recommendations. Some teachers have used these during their post–AP Exam period, whereas others have assigned parts of these works for summer reading.

Bernstein, Peter L. *Against the Gods: The Remarkable Story of Risk*. New York: Wiley, 1996.

Best, Joel. *Damned Lies and Statistics: Untangling Numbers from the Media, Politicians, and Activists*. Berkeley: University of California Press, 2001.

Crossen, Cynthia. *Tainted Truth: The Manipulation of Fact in America*. New York: Simon and Schuster, 1994. The author contends that we are continually awash in "facts" that originate from researchers beholden to corporations.

Desrosières, Alain. *The Politics of Large Numbers: A History of Statistical Reasoning*. Cambridge, Mass.: Harvard University Press, 1998. This is a quite demanding, complex, and sophisticated look at the history of statistics and an analysis of its function within the state.

Dewdney, A. K. *200% of Nothing: An Eye-Opening Tour Through the Twists and Turns of Math Abuse and Innumeracy*. New York: Wiley, 1993.

Glassner, Barry. *The Culture of Fear: Why Americans Are Afraid of the Wrong Things*. New York: Basic Books, 1999. The book deals with popular misconceptions of the relative risk of many activities.

Gould, Stephen Jay. *Full House: The Spread of Excellence from Plato to Darwin*. New York: Harmony Books, 1996. This one is challenging.

Huff, Darrell. *How to Lie with Statistics*. New York: W. W. Norton, 1954.

Levitt, Steven D., and Stephen J. Dubner. *Freakonomics: A Rogue Economist Explores the Hidden Side of Everything*. New York: William Morrow, 2005.

Newport, Frank. *Polling Matters: Why Leaders Must Listen to the Wisdom of the People*. New York: Warner Books, 2004.

Paulos, John Allen. *Beyond Numeracy: Ruminations of a Numbers Man*. New York: Knopf, 1991. Visit Paulos's interesting and thought-provoking home page at www.math.temple.edu/~paulos.

Paulos, John Allen. *Innumeracy: Mathematical Illiteracy and Its Consequences*. New York: Hill and Wang, 1988.

Paulos, John Allen. *A Mathematician Plays the Stock Market*. New York: Basic Books, 2003.

Paulos, John Allen. *A Mathematician Reads the Newspaper*. New York: Basic Books, 1995.

Paulos, John Allen. *Once upon a Number: The Hidden Mathematical Logic of Stories*. New York: Basic Books, 1998.

Professional Reading

This collection of readings will provide you with additional content and pedagogy beyond the level of the course. It may be useful for increasing your understanding of some of the course's key concepts and topics.

American Statistical Association. *Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report*. Alexandria, Va.: American Statistical Association, 2005. www.amstat.org/education/gaise/.

Babbie, Earl. *The Practice of Social Research*. 11th ed. Belmont, Calif.: Thomson/Wadsworth, 2007.

Book, Stephen A. "Why n–1 in the Formula for the Sample Standard Deviation?" *Two-Year College Mathematics Journal* 10 (1979): 330-33.

Box, George E. P., William G. Hunter, and J. Stuart Hunter. *Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building*. New York: Wiley, 1978.

Campbell, Donald T., and Julian C. Stanley. *Experimental and Quasi-experimental Designs for Research*. Chicago: Rand McNally, 1963.

Cleveland, William S. *Visualizing Data*. Summit, N.J.: Hobart Press, 1993.

Cobb, George W. *Introduction to Design and Analysis of Experiments*. New York: Springer, 1998.

Cobb, George W. "Teaching Statistics: More Data, Less Lecturing." In *Heeding the Call for Change: Suggestions for Curricular Action*, ed. Lynn Arthur Steen. Washington, D.C.: Mathematical Association of America, 1992.

Cobb, George W., and David S. Moore. "Mathematics, Statistics, and Teaching." *American Mathematical Monthly* 104 (November 1997): 801-23.

Everitt, B. S. *The Cambridge Dictionary of Statistics*. 3rd ed. Cambridge: Cambridge University Press, 2006.

Gal, Iddo, and Joan B. Garfield, eds. *The Assessment Challenge in Statistics Education*. Amsterdam: IOS Press, 1997.

Garfield, Joan. "How Students Learn Statistics." *International Statistical Review* 63, no. 1 (1995): 25–34.

Garfield, Joan, and Andrew Ahlgren. "Difficulties in Learning Basic Concepts in Probability and Statistics: Implications for Research." *Journal for Research in Mathematics Education* 19 (1988): 44–63.

Garfield, Joan, and Iddo Gal. "Assessment and Statistics Education: Current Challenges and Directions." *International Statistical Review* 67, no. 1 (1999): 1–12.

Gelman, Andrew, and Deborah Nolan. *Teaching Statistics: A Bag of Tricks*. New York: Oxford University Press, 2002.

Gordon, Florence, and Sheldon Gordon, eds. *Statistics for the Twenty-first Century*. Washington, D.C.: Mathematical Association of America, 1992.

Hamilton, Lawrence C. *Regression with Graphics: A Second Course in Applied Statistics*. Pacific Grove, Calif.: Brooks/Cole, 1992.

Hoaglin, David C., and David S. Moore, eds. *Perspectives on Contemporary Statistics*. Washington, D.C.: Mathematical Association of America, 1992.

Law, Averill M. *Simulation Modeling and Analysis*. 4th ed. Boston: McGraw-Hill, 2006.

Lovett, Marcia C., and Joel B. Greenhouse. "Applying Cognitive Theory to Statistics Instruction." *American Statistician* 54, no. 3 (August 2000): 196–206.

Misra, S. Chandra, Hardeo Sahai, Anil P. Gore, and Joseph K. Garrett. “A Bibliography on the Teaching of Probability and Statistics.” *American Statistician* 41, no. 4 (November 1987): 284–310.

Moore, David S. “New Pedagogy and New Content: The Case of Statistics.” *International Statistical Review* 65, no. 2 (1997): 123-65.

Moore, Thomas L. *Teaching Statistics: Resources for Undergraduate Instructors*. Washington D.C.: Mathematical Association of America, 2000.

National Council of Teachers of Mathematics. *Principles and Standards for School Mathematics*. Reston, Va.: National Council of Teachers of Mathematics, 2000. Available electronically for 120-day free access at http://standards.nctm.org.

National Council of Teachers of Mathematics. *Thinking and Reasoning with Data and Chance: 68th NCTM Yearbook*. Reston, Va.: National Council of Teachers of Mathematics, 2006.

Peters, William Stanley. *Counting for Something: Statistical Principles and Personalities*. New York: Springer, 1987.

Rosner, Bernard. *Fundamentals of Biostatistics*. 6th ed. Belmont, Calif.: Thomson Brooks/Cole, 2006.

Ross, Sheldon M. *A First Course in Probability*. 7th ed. Upper Saddle River, N.J.: Pearson/Prentice Hall, 2006.

Shaughnessy, J. Michael, and Beth L. Chance. *Statistical Questions from the Classroom*. Reston, Va.: National Council of Teachers of Mathematics, 2005.

Singer, Judith D., and John B. Willett. “Improving the Teaching of Applied Statistics: Putting the Data Back into Data Analysis.” *American Statistician* 44, no. 3 (August 1990): 223-30.

Print/Online Journals and Newsletters

Journals and newsletters are excellent sources of information on the latest thinking and/or findings in statistics. In addition, they often provide broader perspectives as you expand your understanding of statistics. A collection of the most common journals and newsletters in the field are presented below. Many are available online.

American Statistician.
www.amstat.org/publications/tas.
Published by the American Statistical Association, this publication has an interesting regular feature, “Teacher’s Corner.”

Chance.
www.amstat.org/publications/chance.
Jointly published by the American Statistical Association and Springer, *Chance* is an entertaining magazine about contemporary uses of statistics. It is intended for anyone who has an interest in the analysis of data. *Chance* features articles that showcase the use of statistical methods and ideas in the social, biological, physical, and medical sciences. It also presents material about statistical computing and graphical presentation of data. Through its regular departments and columns, *Chance* keeps its readers informed about developments and ideas in a variety of areas, including government statistics and sports.

Journal of Statistics Education.
www.amstat.org/publications/jse.
JSE is a publication of the American Statistical Association, disseminating knowledge for the improvement of statistics education at all levels, including elementary, secondary, and postsecondary education. It is distributed electronically and, in accord with its broad focus, publishes articles that enhance the exchange of interesting and useful information among educators, practitioners, and researchers around the world. The intended audience includes anyone who teaches statistics, as well as those interested in research on statistical and probabilistic reasoning.

Mathematics Teacher.
www.nctm.org/publications.
This monthly magazine published by the National Council of Teachers of Mathematics offers activities, lesson ideas, teaching strategies, and problems through in-depth articles, departments, and features.

Statistics Teacher Network.
www.amstat.org/education/stn.
This newsletter is published three times a year by the American Statistical Association and the National Council of Teachers of Mathematics Joint Committee on Curriculum in Statistics and Probability. *STN* is a free publication whose purpose is to keep grade K–12 teachers informed about statistical workshops, programs, and reviews of books, software, and calculators. In addition, articles describing successful classroom statistical activities are included.

STATS: The Magazine for Students of Statistics.
www.amstat.org/publications/stats.
STATS magazine, published by the American Statistical Association, contains career information, student experiences, current problems and case studies, humor, and stories from leaders in statistical science. The goal of *STATS* is to promote the field of statistics and make its contributions accessible to a broad audience.

Teaching Statistics: An International Journal for Teachers.
www.blackwell-synergy.com/loi/test?cookieSet=1.
This journal seeks to help teachers of biology, business studies, economics, geography, mathematics, and the social sciences by showing how statistical ideas can illuminate their work and how to make proper use of statistics in their teaching. It is also directed toward those who teach statistics as a separate subject and to those who teach statistics in conjunction with mathematics courses. The emphasis of the articles is on teaching and the classroom. Its aim is to inform, entertain, encourage and enlighten all who use statistics in their teaching or who teach statistics per se.

Multimedia Resources

Multimedia, when used effectively, can be an engaging tool for students in the total learning process for AP Statistics. The following software packages and videos are just some of the many that are available.

Computer Software

<u>Teaching Software</u>

ActivStats.
www.datadesk.com/products/mediadx/activstats.

Fathom.
www.keypress.com/fathom.

Statistics Packages

Data Desk.
www.datadesk.com.

JMP.
www.jmpdiscovery.com.

Minitab.
www.minitab.com/products.
Note: Releases 14 and 15 have many excellent upgrades for elementary data displays. Network and single-user versions are available.

Other Software

R statistical software.
www.r-project/org.
Available for free on the Web at the *R* Project for Statistical Computing.

R FAQs
http://cran.r-project.org/bin/windows/base/rw-FAQ.html.

StatCrunch: Data Analysis on the Web.
www.statcrunch.com.
This used to be free but now must be purchased. It can be downloaded from the Web site.

WinStat.
http://math.exeter.edu/rparris/winstats.html.
This software, by Rick Parris at Phillips Exeter Academy, will do pretty much anything statistical. It is updated regularly.

Commercial Films

And the Band Played On. 1993. Directed by Roger Spottiswoode. HBO. 140 mins. This movie is based on a book by Randy Shilts about the early years of the AIDS epidemic—somewhat controversial but contains lots of statistics. See Zack Bigner's Web site (linked through the AP Statistics FAQ site listed in the Web Sites section of this chapter) for several worksheets about this movie. As in all teaching situations, it is important to know your community norms when deciding whether to use a particular resource.

A Civil Action. 1998. Directed by Steven Zaillian. Touchstone Pictures. 115 mins. The subject is a lawsuit brought against a company for polluting the environment. See the AP Statistics Electronic Discussion Group of May 2004 for several worksheets on this movie.

Educational Films

Against All Odds: Inside Statistics. 1989. Written by David S. Moore. Lexington, Mass.: Consortium for Mathematics and Its Applications (COMAP). 26 half-hour segments. VHS or DVD. Available for online viewing (*not* downloading).
www.learner.org/resources/series65.html.

Statistics: Decisions Through Data. 1992. Written by David S. Moore. Lexington, Mass.: Consortium for Mathematics and Its Applications (COMAP). Five hour-long videos with user's guide (total of 21 video segments). VHS or DVD.
www.comap.com/product/?idx=200.

Web Sites

American Statistical Association. Links to useful applet sites.
www.amstat.org/sections/educ/applets.html.

AP Statistics Course Home Page.
apcentral.collegeboard.com/stats.
AP Central is *the* single, best source for all information and resources relating to AP Statistics. The site is described extensively in chapter 2.

Boggs, Rex. Exploring Data.
http://exploringdata.cqu.edu.au.
This is an excellent site for AP Statistics teaching materials and downloadable activities.

Chance. Materials to help teach a "Chance" course (a quantitative literacy course).
www.dartmouth.edu/~chance.
Includes sample activities, videos, assessments, and archives of *Chance News*—descriptions of recent news articles involving probability and statistics along with suggested discussion questions.

CIA World Factbook.
www.cia.gov/library/publications/the-world-factbook.

Consortium for the Advancement of Undergraduate Statistics Education (CAUSE).
www.causeweb.org.
CAUSE has many resources, among the most valuable to teachers being the extensive set of lesson examples and applets available for teaching statistical concepts. Among the hundreds is one using the criminal trials in the U.S. justice system to illustrate hypothesis testing; another features the creation of 95 percent confidence intervals for the theoretical mean.

Coons, Al. BB&N AP Statistics. Al Coon's AP Statistics class Web site.
www.bbn-school.org/us/math/ap_stats.
An excellent source of links to applets, tests, and projects.

Data and Story Library.
http://lib.stat.cmu.edu/DASL.

Derksen, Jared. AP Statistics FAQ.
www.mrderksen.com/faq.htm.
Frequently asked questions about statistical concepts for new teachers. This site is a subdivision of MrDerksen.com (www.mrderksen.com) and is described in detail in chapter 2. It contains a wealth of information culled from the AP Statistics EDG, along with links to experienced teachers' Web sites, a number of which are also listed here.

Gallup Organization.
www.gallup.com.

Lock, Robin. WWW Resources for Teaching Statistics.
http://it.stlawu.edu/~rlock/maa51/www.html.
An excellent place to look for data sets and other online materials with some commentary.

McGrail, Sheila. AP Stat Resources.
www.ccds.charlotte.nc.us/mcgrail/apsres.htm.

Molesky, Jason. AP Statistics at Lakeville South High School in Minnesota.
http://web.mac.com/statsmonkey.

North Carolina School of Science and Mathematics. NCSSM Statistics Institutes.
http://courses.ncssm.edu/math/Stat_Inst/links_to_all_stats_institutes.htm.
NCSSM has been a great incubator for the creation of teachers' material for AP Statistics. Here you will find a wonderful array of activities, lessons with teachers' notes, and Web-based resources for your use in class. For a new teacher, the material produced during the 2007 institute will the most beneficial starting point.

Rice Virtual Lab in Statistics.
http://onlinestatbook.com/rvls.html
Great site for Java applets that illustrate sampling distributions (outstanding!) and demonstrations for confidence intervals, normal approximation to the binomial, and power, among others.

Smart, Joyce. Mrs. Smart's AP Statistics Page. Teacher site.
www.lhs.logan.k12.ut.us/~jsmart/stats.html.

U.S. Census Bureau.
www.census.gov.

West, Webster. Java Applets.
www.stat.tamu.edu/~west/javahtml.

Assessment Sites

ARTIST (Assessment Resource Tools for Improving Statistical Thinking).
https://app.gen.umn.edu/artist/index.html.
Here students can take online multiple-choice quizzes that are topic specific. The site also offers pre- and post-tests, as well as a large database that can be searched for items to add to a test or quiz. It is also possible to create a test or quiz at the site, then download it to your computer in Microsoft *Word*.

Schott, Brian, Georgia State University. Database of Sample Statistics Quiz Questions.
www.gsu.edu/~dscbms/ibs/ibsd.html.

Schott, Brian, Georgia State University. Practice Questions for Business Statistics.
www.gsu.edu/~dscbms/ibs/qcontent.html.
Through an NSF grant, the Department of Business Statistics at Georgia State University has developed a large collection of useful test questions, both multiple-choice (see the previous entry) and free-response (this one).

Simon Fraser University, Department of Statistics and Actuarial Science. SFU Statistics Multiple-Choice Questions.
www.stat.sfu.ca/~cschwarz/MultipleChoice
A wonderful assortment of multiple-choice questions, with answers, that can be used on tests and for exam review preparation.
See also Long Answer Questions, also on the Simon Fraser site:
www.stat.sfu.ca/~cschwarz/LongAnswer/.

Calculator Company Sites

Casio.
www.casio.com.

Hewlett-Packard.
www.hp.com/calculators.

Sharp.
www.sharpusa.com/products.

Texas Instruments.
www.education.ti.com.

Professional Associations

As a new teacher of AP Statistics, another way to stay current in the discipline is to join one or more professional organizations.

American Mathematical Association of Two-Year Colleges
Southwest Tennessee Community College
5983 Macon Cove
Memphis, TN 38134
901 333-4643
www.amatyc.org
E-mail: amatyc@amatyc.org

American Statistical Association
732 North Washington Street
Alexandria, VA 22314-1943
703 684-1221; 888 231-3473
www.amstat.org
E-mail: asainfo@amstat.org
Click on the *Education* link in the sidebar to bring up the Center for Statistics Education. The *Education* menu also has a link to the *Statistics Teacher Network*, where you can sign up to receive the newsletter, browse older issues, and link to materials for K–12 statistics. A K–12 school membership is currently $50. You receive *STATS* and *Chance* magazines as part of the membership, as well as the *Statistics Teacher Network* newsletter.

Consortium for the Advancement of Undergraduate Statistics Education
Ohio State University, Department of Statistics
404 Cockins Hall
1958 Neil Avenue
Columbus, OH 43210-1247
614 292-3887
www.causeweb.org
E-mail: info@causeweb.org

Mathematical Association of America
1529 18th Street NW
Washington, DC 20036-1385
202 387-5200; 800 741-9415
www.maa.org
E-mail: maahq@maa.org

National Council of Teachers of Mathematics
1906 Association Drive
Reston, VA 22091-1502
703 620-9840
www.nctm.org
E-mail: inquiries@nctm.org

This section on information sources has presented a blueprint for establishing a core group of resources and then adding to it over time. Given the large amount of material that I have assembled, this may seem to be an overwhelming task. Just as a museum builds its art collection over time, so too should this chapter be thought of as a long-term plan for the acquisition of a statistical collection. Do not expect it to happen overnight. During my first year, in 1996, I concentrated on the textbook, gathered news articles on a regular basis to use in class, screened some videos, and worked on some data-gathering activities. In subsequent years I added to my repertoire. Be realistic about what you can accomplish—maybe it is just the textbook, a review guide, some news articles, and a single project in your first year. Try to do a bit more the second year.

I encourage you to regularly peruse the resources on AP Central and experienced teacher Web sites. If you go to a conference, seek out the sessions that are about statistics. Talk to other statistics teachers, and ask them not only what favorite resources they use but *how* they use them in the classroom. I have obtained much useful information over a cup of coffee or standing in line waiting for a session.

Best wishes as you embark on a truly wonderful teaching experience. For me, AP Statistics has been a richly rewarding and fun course to teach. As many students have said to me, "I never had to ask, 'When am I ever going to use this?' "

How to Address Limited Resources

Teachers in certain schools may face distinct challenges, such as small enrollments or limited budgets. In those cases, keep in mind that the number one free resource for all teachers is AP Central. Every AP Statistics teacher should be registered there in order to take advantage of the large amount of support material conveniently available:

- The *AP Statistics Course Description*
- Reviews of textbooks, teaching materials, and Web sites

- Section II (free-response) questions and scoring guidelines from past exams
- An AP Statistics Practice Exam with scoring guidelines and multiple-choice answer key
- Sample syllabi and articles on teaching the course
- Link to the AP Statistics Electronic Discussion Group, where you will find other teachers interested in statistics pedagogy
- Link to the College Board Store, where you can purchase Released Exams and supplemental materials, such as the sampling and experimental design module
- Link to information on Professional Development opportunities such as AP Summer Institutes and workshops and online events

Spending Wisely

For those of us operating with a limited budget, the essential issue is how best to allocate what money is available. Two items are not negotiable, in my opinion. The textbook must be modern enough to cover the whole AP syllabus, and each student must have a graphing calculator with statistical capability. My students all own their own calculators, but a classroom set purchased by the school will suffice if they can use them at home.

Next in order of priority is access to computers with statistical software. Students are expected to know how to read computer output when they take the AP Statistics Exam. Clearly, students' understanding will improve if they produce the output, so even one computer for individual student use or demonstrations is advisable. At my school we bought a site license for the software and have it installed on computers in a computer lab. I just need to reserve the lab in advance to take the class there.

There are creative ways to overcome either budget or size restrictions. I have been doing an experiment comparing brands of paper towels by trading classrooms with a science teacher so we have access to water. (This experiment is modeled after one done at a Statistics Leadership Institute held at the North Carolina School of Science and Mathematics; see http://courses.ncssm.edu/math/Stat_Inst/PDFS/PaperTow.pdf.)

We have also used local supermarkets for data collection activities, such as recording the sugar content shown on the boxes in the cereal aisle. Each student purchases a small bag of Skittles® so that we can check distribution of colors in the bags. These days a lot of product and/or nutritional information is available directly from stores and restaurants or can be accessed online. Finding free or inexpensive materials for your course shouldn't be difficult: a little imagination is all that is required.

—Dennis Holland, The Derryfield School,
Manchester, New Hampshire

Here are some other strategies that may help you deal with limited resources.

- Form a support group by finding other statistics teachers in your area. If you attend an AP Summer Institute (which I absolutely recommend) or a local/regional workshop, be on the lookout for others in your area. Post a sign-up list at the conference to get your local group started. Try to meet several times a year to discuss statistics. Pool your resources by sharing tests, quizzes, activities that worked well, review materials, textbooks, and supplies. Sometimes buying in bulk makes it worthwhile.
- You may be the only statistics teacher in your school, with no one to talk to on a regular basis. Maintain contact with your group via e-mail.

- If you attend an AP Summer Institute, the lead teacher is likely to provide you with lots of good material. Try to maintain a relationship with that person. I am still in contact with participants from six or seven years ago, who will occasionally e-mail me a question.
- The College Board, through the AP Fellows program, can help qualified candidates with funding so that they can attend AP Summer Institutes. See the subsection on AP Grants in the Professional Development section that begins on the next page.
- Use free online statistical software if you are unable to purchase software or do not have direct access to a computer lab (see the list of software that appeared earlier in this chapter).
- Make full use of your textbook's Web site. There are likely to be lots of support materials there—tests and quizzes, textbook solutions, applets, and classroom demonstrations.
- If you order enough textbooks, many companies will include the ancillary materials at no cost. Ask!
- Collaborate with a local university. Find a professor who teaches statistics, and establish a collaborative relationship. Invite the professor to give a guest lecture. Contact the ASA to find out if any members live in your area. Many are interested in helping out.
- Develop a plan to ensure that all students have access to a graphing calculator.
- Look for a local company that might be willing to partner with the statistics program in your school to provide funds for some extra teaching materials, calculators, or other useful items that would otherwise break your department's budget.
- Investigate whether your state has special funds for AP Programs that you can access.
- Look for simple things to do that might be free.

Get Creative with Small Classes

In a small school setting, resources may be scarce, but that does not mean that the instruction provided must suffer. Although it is essential that each student has a text and a calculator with statistics functions that can be brought home to use on homework, a course can easily be supplemented without purchasing statistics software. An abundance of Web sites are available with applets that work very well for demonstrating major topics. Many other demonstrations and simulations can easily be conducted on a calculator.

A teacher must be creative in other ways as well, especially when class sizes are very small (10 or fewer). Sampling students in a small class is not as effective as in a large one, but you might be able to collect data from the whole school. In some ways this is better, as students have to decide on reasonable ways to randomize while obtaining a sample large enough to draw meaningful conclusions. Pooling results in a simulation, for example, may require that each student repeat the process quite a few times. The data from one year can be saved and added to the next. Inexpensive materials such as breakfast cereal, colored candies, or paper clips may be used for data.

—Chris True, Lincoln Southwest High School,
Lincoln, Nebraska

Talk Is Cheap

Each year after the AP Statistics Exam, I invite a guest speaker to address my classes. The speakers have always exceeded my expectations. They describe their "education-to-career" journey as well as the ways they use statistics in their work. Past speakers have been a university professor, an information researcher, and two pharmaceutical statisticians. One good practice is to have students write questions ahead of time and e-mail them to the speaker.

It is not hard to find engaging speakers. One was the parent of one of my students; one was discovered by simply e-mailing a company with a concise description of what I was looking for; and another was located by e-mailing the local ASA chapter for a contact. All methods have produced competent and willing (and free!) speakers.

—Dave Ferris, Noblesville High School,
Noblesville, Indiana

Professional Development

In this section, the College Board outlines its professional development opportunities in support of AP educators.

The teachers, administrators, and AP Coordinators involved in the AP and Pre-AP Programs compose a dedicated, engaged, vibrant community of educational professionals. Welcome!

We invite you to become an active participant in the community. The College Board offers a variety of professional development opportunities designed to educate, support, and invigorate both new and experienced AP teachers and educational professionals. These year-round offerings range from half-day workshops to intensive weeklong summer institutes, from the AP Annual Conference to AP Central, and from participation in an AP Reading to Development Committee membership.

Workshops and Summer Institutes

At the heart of the College Board's professional development offerings are workshops and summer institutes. Participating in an AP workshop is generally one of the first steps to becoming a successful AP teacher. Workshops range in length from half-day to weeklong events and are focused on all 37 AP courses and a range of supplemental topics. Workshop consultants are innovative, successful, and experienced AP teachers; teachers trained in Pre-AP skills and strategies; college faculty members; and other qualified educational professionals who have been trained and endorsed by the College Board. For new and experienced teachers, these course-specific training opportunities encompass all aspects of AP course content, organization, evaluation, and methodology. For administrators, counselors, and AP Coordinators, workshops address critical issues faced in introducing, developing, supporting, and expanding Pre-AP and AP programs in secondary schools. They also serve as a forum for exchanging ideas about AP.

While the AP Program does not have a set of formal requirements that teachers must satisfy prior to teaching an AP course, the College Board suggests that AP teachers have considerable experience and an advanced degree in the discipline before undertaking an AP course.

AP Summer Institutes provide teachers with in-depth training in AP courses and teaching strategies. Participants engage in at least 30 hours of training led by College Board–endorsed consultants and receive printed materials, including excerpts from AP Course Descriptions, AP Exam information, and other course-specific teaching resources. Many locations offer guest speakers, field trips, and other hands-on activities. Each institute is managed individually by staff at the sponsoring institution under the guidelines provided by the College Board.

Participants in College Board professional development workshops and summer institutes are eligible for continuing education units (CEUs). The College Board is authorized by the International Association for Continuing Education and Training (IACET) to offer CEUs. IACET is an internationally recognized organization that provides standards and authorization for continuing education and training.

Workshop and institute offerings for the AP Statistics teacher (or potential teacher) range from introductory to topic-specific events and include offerings tailored to teachers in the Pre-AP years. To learn more about scheduled workshops and summer institutes near you, visit the Institutes and Workshops area on AP Central: apcentral.collegeboard.com/events.

Online Events

The College Board offers a wide variety of online events, which are presented by College Board–endorsed consultants and recognized subject-matter experts to participants via a Web-based, real-time interface. Online events range from one hour to several days and are interactive, allowing for exchanges between the presenter and participants and between participants. Like face-to-face workshops, online events vary in focus from introductory themes to specific topics, and many offer CEUs for participants. For a complete list of upcoming and archived online events, visit apcentral.collegeboard.com/onlineevents/schedule.

Archives of past online events are available for free. Archived events can be viewed on your computer at your convenience.

AP Central

AP Central is the College Board's online home for AP professionals and Pre-AP. The site offers a wealth of resources, including Course Descriptions, sample syllabi, exam questions, a vast database of teaching resource reviews, lesson plans, course-specific feature articles, and much more. Bookmark the AP Statistics Home Page on AP Central to gain quick access to updated resources and information about AP Statistics.

AP Program information is also available on the site, including exam calendars, fee and fee-reduction policies, student performance data, participation forms, research reports, college and university AP grade acceptance policies, and more.

AP professionals are encouraged to contribute to the resources on AP Central by submitting articles, adding comments to Teachers' Resources reviews, and serving as an AP Central Content Advisor.

Electronic Discussion Groups

The AP Electronic Discussion Groups (EDGs) were created to provide a moderated forum for the exchange of ideas, insights, and practices among AP teachers, AP Coordinators, consultants, AP Exam Readers, administrators, and college faculty. EDGs are Web-based threaded discussion groups focused on specific AP courses or roles, giving participants the ability to ask and answer questions online for viewing by other members of the EDG. To join an EDG, visit apcentral.collegeboard.com/community/edg.

AP Annual Conference

The AP Annual Conference (APAC) is a gathering of the AP and Pre-AP communities, including teachers, secondary school administrators, and college faculty. The APAC is the only national conference that focuses on providing complete strategies for middle and high school teachers and administrators involved in the AP Program. Conference events include presentations by each course's Development Committee, course- and topic-specific sessions, guest speakers, and pre- and postconference workshops for new and experienced teachers. To learn more about the event, please visit collegeboard.com/apac.

AP professionals are encouraged to lead workshops and presentations at the conference. Proposals are due in the fall of each year prior to the event (visit AP Central for specific deadlines and requirements).

Professional Opportunities

College Board Consultants and Contributors

Experienced AP teachers and educational professionals share their techniques, best practices, materials, and expertise with other educators by serving as College Board consultants and contributors. They may lead workshops and summer institutes, sharing their proven techniques and best practices with new and experienced AP teachers, AP Coordinators, and administrators. They may also contribute to AP course and exam development (writing exam questions or serving on a Development Committee) or evaluate AP Exams at the annual AP Reading. Consultants and contributors may be teachers, postsecondary faculty, counselors, administrators, and retired educators. They receive an honorarium for their work and are reimbursed for expenses. To learn more about becoming a workshop consultant, visit apcentral.collegeboard.com/consultant.

AP Exam Readers

High school and college faculty members from around the world gather in the United States each June to evaluate and score the free-response sections of the AP Exams at the annual AP Reading. AP Exam Readers are led by a Chief Reader, a college professor who has the responsibility of ensuring that students receive grades that accurately reflect college-level achievement. Readers describe the experience as providing unparalleled insight into the exam evaluation process and as an opportunity for intensive collegial exchange between high school and college faculty. (More than 10,500 Readers participated in the 2008 Reading.) High school Readers receive certificates awarding professional development hours and CEUs for their participation in the AP Reading. To apply to become an AP Reader, go to apcentral.collegeboard.com/readers.

Development Committee Members

The dedicated members of each course's Development Committee play a critical role in the preparation of the Course Description and exam. They represent a diverse spectrum of knowledge and points of view in their fields and, as a group, are the authority when it comes to making subject-matter decisions in the exam-construction process. The AP Development Committees represent a unique collaboration between high school and college educators.

AP Grants

The College Board offers a suite of competitive grants that provide financial and technical assistance to schools and teachers interested in expanding access to AP. The suite consists of three grant programs: College Board AP Fellows, College Board Pre-AP Fellows, and the AP Start-Up Grant, totaling over

$600,000 in annual support for professional development and classroom resources. The programs provide stipends for teachers and schools that want to start an AP program or expand their current program. Schools and teachers that serve minority and/or low-income students who have been traditionally underrepresented in AP courses are given preference. To learn more, visit apcentral.collegeboard.com/apgrants.

Our Commitment to Professional Development

The College Board is committed to supporting and educating AP teachers, AP Coordinators, and administrators. We encourage you to attend professional development events and workshops to expand your knowledge of and familiarity with the AP course(s) you teach or that your school offers, and then to share that knowledge with other members of the AP community. In addition, we recommend that you join professional associations, attend meetings, and read journals to help support your involvement in the community of educational professionals in your discipline. By working with other educational professionals, you will strengthen that community and increase the variety of teaching resources you use.

Your work in the classroom and your contributions to professional development help the AP Program continue to grow, providing students worldwide with the opportunity to engage in college-level learning while still in high school.