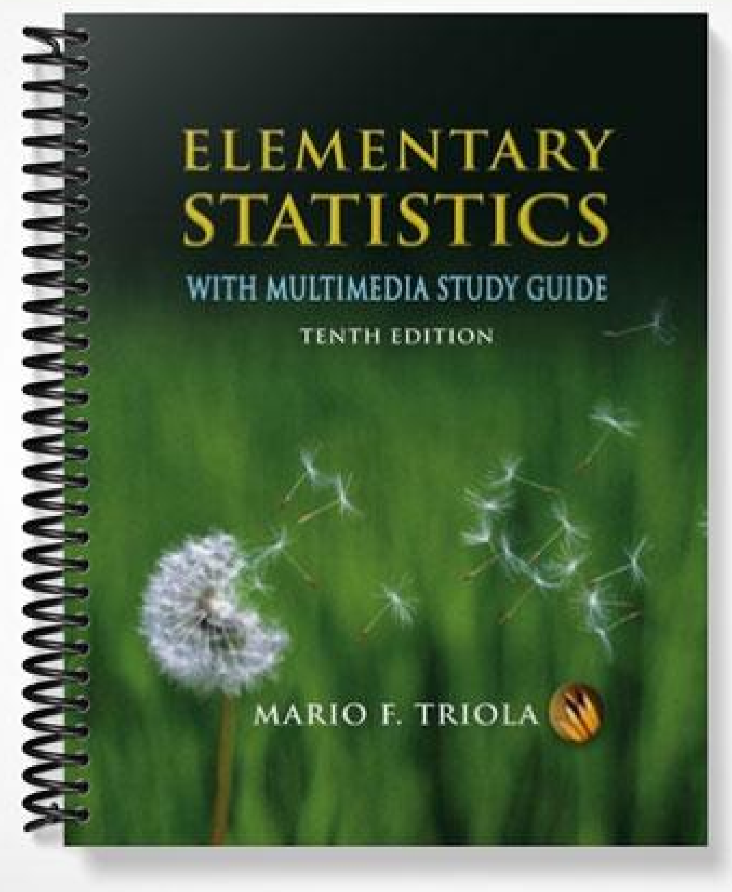
SOLUTIONS MANUAL



II. How should statistics be taught?

One of the most important points to be made in this *Insider's Guide* is the basic approach to teaching the introductory statistics course. Here are some important principles:

1. The introductory statistics course should be taught in a way that is fundamentally different from the approach used in traditional mathematics courses. The arithmetic computations are not nearly as important as the ability to *understand* results and to be able to *interpret* results in a meaningful way.
2. The introductory statistics course focuses on real applications instead of abstractions.
3. Books in the Triola statistics series are full of real data. Examples, exercises, and test questions should involve students with real data as much as possible. Fabricated data have little or no use in the introductory statistics course.
4. There should not be a high priority placed on covering as many different topics as possible. It is much better to cover fewer topics well than to cover many topics poorly.

The following pages identify the GAISE recommendations. The author comments included about the GAISE recommendations are designed to clarify the above points.

GAISE Recommendations

GAISE is an acronym for "Guidelines for Assessment and Instruction in Statistics Education." These guidelines are recommendations from a project sponsored by the American Statistical Association (ASA). Here are six GAISE recommendations for the teaching of introductory statistics:

1. **Emphasize statistical literacy and develop statistical thinking;**

2. **Use real data;**

3. **Stress conceptual understanding rather than mere knowledge of procedures;**

4. **Foster active learning in the classroom;**

5. **Use technology for developing conceptual understanding and analyzing data;**

6. **Use assessments to improve and evaluate student learning;**

The author enthusiastically supports these recommendations, and much of the content of this *Insider's Guide* is devoted to implementation of these recommendations. Here are some comments about the six recommendations.

1. **Emphasize statistical literacy and develop statistical thinking.**
The importance of sound sampling techniques should be introduced early and often throughout the introductory statistics course. Part of "literacy" is understanding the meaning of terms such as *simple random sample* and *voluntary response sample*. Statistical thinking is used when a student recognizes that results obtained from a poorly selected sample might be results without any real validity. For example, newspapers, magazines, television shows, and Internet sites often conduct surveys by asking people to respond to some question. However, the responses constitute a voluntary response sample, and students should know that any conclusions based on such a sample do not apply to the larger population of all Americans. This is one simple example of the type of critical thinking that should be fostered throughout the course.

In teaching the introductory statistics course, it is not important to memorize formulas or the detailed mechanics of statistical methods. It is not important to be able to reproduce the formula for the standard deviation *s*, and it is not so important to be able to do the arithmetic required for manually computing values of standard deviations. Instead, it is important to *understand* what the standard deviation *s* measures. On a very basic level, it is important for students to know quite well that *s* is a measure of *variation*. It is *really* important that students develop an ability to *understand* and *interpret* values of the standard deviation *s*. The empirical rule and Chebyshev's theorem are commonly presented as tools that help students understand and interpret *s,* but the author recommends skipping those two topics and focusing instead on the *range rule of thumb* presented in the book. It is easy to apply, and students generally understand it quite well, so it becomes a very effective tool that can help students understand and interpret values of standard deviations. This topic will be discussed further when measures of variation are discussed later in this guide. But this topic is excellent for making the point that we should emphasize statistical literacy and develop statistical thinking.

When teaching an introductory calculus course, the author might give a test question that asks students to write the definition of the derivative of the function $f(x)$, and he might ask students to compute the derivative of $f(x) = x^2$ while showing all of the steps involved. Calculus students should know the definition of the derivative and they should be able to apply it. However, the author would never ask statistics students to write the formula for the standard deviation or to calculate the standard deviation of a list of values while showing all work. Instead, the author prefers to ask questions that test *understanding*. Here are examples of good and bad test questions:

Bad test question: Write the formulas for the mean and standard deviation s, then compute the mean and standard deviation of the values 23.7, 11.2, 43.5, 77.2, 49.0, 27.3, and show all work.

Good test question: Listed below are weights (in grams) of newly minted quarters. (a) Find the mean. (b) Find the standard deviation. (c) In the context of the given weights, is a weight of 5.23 g *usual* or *unusual*? Explain your choice. (d) What is an adverse consequence of minting quarters with weights that vary too much?

5.71 5.71 5.59 5.61 5.63

When students find the mean $\bar{x}$ = 5.650 g and standard deviation of s = 0.057 g, they should be encourage to use some technology, such as a TI-83 Plus or TI-84 Plus calculator. There is little to be gained by requiring that such statistics be calculated manually. A good answer to part (b) of the preceding question is the statement that yes, a weight of 5.23 g would be unusual because it is more than two standard deviations away from the mean. One of several good answers to part (c) would be a statement that if weights of minted quarters vary too much, vending machines will reject too many valid coins. Part (c) is designed to emphasize the point that methods of statistics have real, important, and meaningful applications instead of being abstract concepts that might not have any real applications.

2. Use real data

George Cobb is a leader in statistics education. He wrote an article about evaluating introductory statistics textbooks (see "Introductory Textbooks: A Framework for evaluation", *Journal of the American Statistical Association*, Vol. 82, No. 397) and he included this statement:

> ***"Are the Data Sets Real or Fake? Not that many years ago, all it took was this first question to dispatch most books to the morgue. Fortunately, that is changing. It is true that there are still books on the market whose examples have been bled white of vital detail, but it is now easier to shun them. I hope that soon we will have seen the last of the infamous XYZ Corporation and Hospitals A, B, C, ..."***

With real data, students see how statistical concepts have meaningful applications. Hopefully, they will encounter data from the discipline that they might be considering as a major.

3. Stress conceptual understanding rather than mere knowledge of procedures
A good illustration of this point can be seen in the data from eruptions of the Old Faithful geyser and data from forecast and actual low temperatures:

Duration (sec)	240	120	178	234	235	269	255	220
Interval After (min)	92	65	72	94	83	94	101	87

Actual low (^oF)	54	54	55	60	64
Low forecast five days earlier (^oF)	56	57	59	56	64

When discussing correlation/regression, we might present the top table and ask if there is a correlation between the duration of an eruption and the time interval after the eruption to the next eruption. When discussing matched data, we might present the second table given above, and we might ask if the differences between the actual and forecast temperatures are from a population with a mean of 0. But instead of focusing too much on the details of the computations involved, we should stress the fundamental difference between the two sets of data summarized in the preceding tables. Students should learn how to ask the best questions. Given the first table above, students should see that the issue is one of a *relationship* between the two variables. Given the second table above, students should see that a key element is the list of *differences* between the actual and forecast temperatures, and a mean difference equal to zero is evidence that the forecast temperatures are accurate. It's not the structure of paired data that determines the method that is most appropriate, it is the *context* of the data.

4. Foster active learning in the classroom
Here is an old saying that is so true when considered in the context of teaching an introductory statistics course:

> *Tell me something, and I will forget.*
> *Show me and I will remember.*
> *Involve me, and I will learn.*

If you want your students to have a learning experience that will affect them for their entire lives, *involve* them with active learning. The textbook has Cooperative Group Activities at the end of each chapter. Also, see Chapter 15 of *Elementary Statistics,* 10th edition, for a long list of additional project topics.

Some statistics professors believe that the entire course should be based on activities, and some other statistics professors do not include any activities at all. Somewhere between these extremes is a balance that allows active involvement along with enough time for teaching concepts using traditional methods.

Recommendation: If you do no activities at all, begin with just one or two activities to see how well they work. Then, assuming that all goes well, incorporate more activities in your course in the future.

5. Use technology for developing conceptual understanding and analyzing data

Many statistics professors teach an effective course by allowing students to use any one of a variety of different scientific calculators. The author recommends that a specific technology be used. The Triola statistics books include displays from STATDISK, Minitab, Excel, and a TI-83/84 Plus calculator. There are also supplements for SPSS and SAS.

The author's personal preference is to require that each student have a TI-83 Plus or TI-84 Plus calculator, and that each student also do several software projects using STATDISK. However, choosing a technology to be used for an introductory statistics course is a complex decision that must take several factors into account. Some colleges have adopted a decision to use Excel because so many students use Excel in their work after graduation. Some colleges avoid Excel because its statistics functions are not as good as they should be. Some colleges use Minitab, and the latest release includes features that make it a perfectly good choice. Some statistics professors prefer to require TI-83/84 Plus calculators because they can do so much statistical number crunching and they can be used in class and on tests. Some statistics professors would like to require TI-83/84 Plus calculators, but are reluctant to do so because of their cost. The author had that same concern the first time that he required those calculators, so he announced that any students could sell their calculators at the end of the course. At the end of that semester, *no* students wanted to give up their calculators. Their desire to keep their calculators instead of turning them in for cash was a strong indication about how they perceived the usefulness of those calculators.

STATDISK STATDISK is a free easy-to-use software package designed specifically for the Triola statistics books. The latest version of STATDISK is one that the author is proud to have as a major and important supplement. It has been completely recoded and tested since the last release. Because STATDISK can do almost all of the functions described in the textbook, it can be used as the technology in the introductory statistics course. If another technology, such as Excel or SPSS, is used as the major technology, it would be really helpful to have students use STATDISK as a supplement to the main technology being used.

Technology for New Approaches The technology can do the statistics number crunching, but it should also be used to explore concepts and new approaches. When considering the effects of an outlier, for example, a hypothesis test could be conducted with the outlier included and again with the outlier excluded. Probability can be better studied with simulations. Bootstrap resampling techniques can sometimes be used when traditional methods should not be used. For ideas about how to include technology, see the Technology Projects at the ends of the chapters

6. Use assessments to improve and evaluate student learning

Traditional tests and quizzes are one important method of assessment, but there are others. The author favors the use of activities and at least one major project. The author favors a capstone group project conducted near the end of the course. Students can work together in groups of four (more or less), and each group should conduct a project that involves the planning of an experiment or a method for collecting data in an observational study. After collecting original data, the group will make an inference by using the methods learned in the course. A group presentation would involve each member speaking for at least a minute or two. A computer display would also be included, along with a brief written report. Assessment is an important component of such a project. How do you assess the work of individual members that participate in a group project? Here is a one method that the author found to be effective: Survey each group member and ask him or her to assess the work done by the other group members. For example, ask each group member to submit a separate form for each other group member. The form should include the name of the other group member and an assessment of their work, such as "was a major contributor to the project," "did an average amount of work on the project," "did some but little work on the project," or "did not participate in any meaningful way." Students are quite honest about the work of their peers, and they along with their peers are quite satisfied with this process of assessment.

The author favors four or five tests given during the semester, along with a comprehensive final examination. Activities and projects should also be part of the assessment plan.