

# Teaching Statistics With Web Technology: The WISE Project

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The Web Interface for Statistics Education (WISE) aims to enhance student learning and understanding of core statistical concepts. The project includes a comprehensive World Wide Web site with links to electronic journals, archived discussion lists, datasets, and interactive tutorials. The statistical concepts addressed by the WISE tutorials are relevant to undergraduate and graduate instruction in any field—such as psychology, economics, or biology—that uses statistical methodology.

## Teaching Statistics

Traditionally, the teaching of statistics emphasizes working through problems in a “cookbook” fashion. This approach tends to emphasize computation while ignoring the relevance of statistics as a tool for enhancing the understanding of data. That is, students are encouraged to learn the “how” but not the “why” or “what for.” It is our belief that traditional approaches often fail to produce effective learning of critical statistical concepts and often are not conducive to creating a continuing interest in statistics. WISE was created to help faculty and students overcome these difficulties of learning core concepts in statistics.

## Using Web Technology

The WISE project provides Internet-based tutorials to supplement the teaching of a variety of statistical concepts. Tutorials include interactive JAVA applets, guided demonstrations of topics, multiple-choice questions with feedback, and “thought” questions to test student understanding and shape classroom discussion. WISE tutorials are unique in that they provide detailed assignments that allow faculty to integrate technology into instruction easily. Interested faculty can simply plug in one of our tutorials as a laboratory exercise or a homework assignment.

Our tutorials focus on core statistical concepts that are essential to a detailed and complete understanding of statistical procedures and reasoning.

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For example, null hypothesis testing procedures (such as t-test, Analysis of Variance, and Chi-square tests of independence) are a primary focus of most introductory statistics courses. These procedures are often learned by rote; students learn a step-by-step approach to drawing correct conclusions. The student is taught to reject the null hypothesis if a computed value is larger than a comparison value and not to reject the null hypothesis if the value is smaller than the comparison value. Unfortunately, teaching hypothesis testing by rote does little to establish an understanding of the procedure; rather, it allows for correct answers without an appreciation of the logic behind decisions. Such misunderstandings are the basis for much of the misapplication of null hypothesis significance testing, which has recently attracted strong criticism.

Several of the WISE tutorials address hypothesis testing in greater depth than is practical with traditional methods. One tutorial teaches concepts related to the Central Limit Theorem and sampling distributions, concepts essential to understanding why we can draw statistical conclusions based on hypothesis testing procedures. Another tutorial examines the logic of hypothesis testing and discusses the meaning of conclusions based on these procedures. A third tutorial teaches concepts related to the power of a statistical test (the ability to reject false hypotheses). There is a discussion of some of the limitations of hypothesis testing procedures while at the same time understanding the reasoning behind statistical conclusions is enhanced.

### **Impact on Teaching**

When we first used WISE tutorials in the classroom, we needed to spend class and laboratory time instructing students in how to use a Web browser and the applets contained in the tutorials. Most students in our classes now have experience with Web browsers and applets.

In addition to the learning that occurs in the lab, the Web-based tutorials contain “follow-up” questions that often spark class discussion. Although leading discussion in a statistics class is often more difficult than structured lecturing, we find that the high level of student engagement generates especially productive exchanges, often focused around the need to consider multiple issues. Contrary to the perceptions of most students, there is not always a single correct answer for statistics problems. Discussions comparing statistical results to practical real-world concerns can be useful. Once this connection is explored and better understood, presentation of topics necessarily becomes more complex, multi-faceted, and challenging to both students and professor.

## Barriers to Computer-Based Learning

The self-paced, independent nature of online tutorials offers great flexibility to students. However, this flexibility has the potential to magnify study skill problems. In the traditional classroom environment, instructors can pace their lectures to fit students' progress. When students are left on their own with an online tutorial, they may not have the skills needed to pace themselves appropriately. Research from the field of cognitive psychology tells us that self-regulation of learning is an especially important consideration with online tutorials, where students work independently and at their own pace. Without guidance, students may move too quickly through assignments, and as a result, may fail to learn.

We gave careful attention to principles of learning as we designed the WISE tutorials, and the tutorials have benefited. Each tutorial forces students to stop and answer questions before proceeding to more detailed material. Reflective exercises are used to ask students to explain the concepts that they are learning and to discuss how concepts apply to the problems at hand. Students answer multiple-choice questions throughout the course of the tutorial. Each question is structured so that students cannot proceed until they answer correctly. Each wrong answer corresponds to a common misconception or misunderstanding. The choice of a wrong answer leads to feedback that addresses the student's misconception. The choice of correct answers reinforces student learning and allows students to gauge how much they are learning. In this manner, students must think about the topics and demonstrate understanding before moving on to new material.

## Impact on Student Learning

We have made a concerted effort to evaluate the impact of the WISE tutorials on student learning. In a test of the effectiveness of our Central Limit Theorem tutorial, we conducted a study with students enrolled in several introductory statistics classes who used the tutorial or attended a lecture on the topic. The group that used the tutorial performed as well as those who attended the lecture.

Evaluations of our tutorials indicated that most students rated the presentation style as useful, found the instruction easy to understand, and rated statistical explanations as clear. Additionally, most students indicated an interest in using tutorials to learn other topics.

To use the WISE tutorials, visit <http://wise.cgu.edu> on the Web. What you'll find is only a beginning. We have yet to take full advantage of the Internet's capability for delivery of highly interactive and effective personal instruction.