TEACHING STATISTICS USING TECHNOLOGY

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This paper handles the use of technology in teaching statistics at the college level. It distinguishes between teaching statistics at an introductory level in core courses, and integrating statistics as "tools" in different disciplines, and teaching statistics as a science for specialized students. Teaching objectives are different for each category, and thus teaching methods should also be different. While stress is given to computations and how they are done using calculators in some classes, emphasis is given to concepts and their meanings in others where the use of technology promotes active learning, enhances the teaching objectives which in turn influences the method statistics is taught and introduced.

INTRODUCTION

Today, we depend on computers and on technology to perform our data analysis. With computers, statistical analyses are used for decision-making using software packages. With software packages there are no worries about programming tasks, and managers today focus on *which* statistical procedure is appropriate and on *how* to interpret results.

Computers do a wonderful job in the construction of graphs and charts and they ease the tedious computations. SAS, SPSS, and MINITAB are widely used statistical software packages; Excel could also be used to ease the computations. Multimedia allows user to seek information and construct knowledge, it relies on problem solving as a basis for understanding, and it helps to illustrate abstract principles or concepts (listing to statistical software provider is available at www.stata.com). When we use computers and technology in teaching statistics, we need to focus on two points (Morse, 1993):

1. Computers perform numerical computations without any regard to the accuracy of the data.
2. Computers follow the instructions whether or not the procedure is legitimate and fit the nature of the data. The computer will not object when asked to compute the average of nominal data. The computer cannot change the nature of the data to make an inappropriate test appropriate. The user, not the computer, is responsible for requesting the proper statistical procedure.

Using technology can make college teaching more effective. It improves the quality of instructions, motivates the learning process, encourages students' active learning in the form of participations and feedback at their own pace, in the course, and provides students with the psychological incentives they need to work hard (Garfield, 1995).

Technology can achieve three important goals (Lock, 1999): (a) encourage students to think like experts, getting them to understand the problem solving processes and critique solutions to problems, (b) see the way students think, so it focuses on the process of learning not just the results, and (c) build up knowledge on what students already know.

TEACHING OBJECTIVES

The essential principle in teaching in general, is to determine what are we trying to accomplish with our students. If goals are met by using conventional teaching strategies and without using technology, it may not be wise to spend time and energy on technology.

I need to distinguish here between teaching a statistics class as a required class, and teaching statistics to a professional (to-be) statistician; also to distinguish between teaching statistics by a statistics specialist and by the non-specialists. The teaching objectives for these four categories are different, and thus teaching methods are also different. If technology is assisting in achieving the established objectives, it should be used but not be looked at as a replacement for the traditional classroom instructions. Courses should be designed with basic teaching objectives in mind, and developed such that students are aware of the process of learning.

THE CONFLICT

Computational formulas simplify computations but give little insights into the meaning of statistics. Definitional formulas better describe the meaning of statistics but are extremely tedious and boring, most of the time, when doing large-scale computation.

Introductory statistics courses are required for many disciplines and offered (sitting side by side) to both the statistician (to-be) specialists and the non-specialists. Classes are usually large (in the business school where I teach, there are over 1000 students in each class). Students usually end up knowing how to, mechanically, do the computations using a calculator, but had little insights into what they were doing, why they did it and when to use it. I mentioned in one of my junior year classes that multiplication is a repeated addition and division is a repeated subtraction, to the majority of students this was a puzzle, though they know how to do multiplications and divisions by hand or by using a calculator. Thus, students at any introductory level do not give enough, or may be any, depth to what they are doing. All that concerns them is " what type of questions will be included in the exam", and the type will direct them on how to study to pass the test, and when tested they want the question to explicitly specify the technique to be used.

Using technology, in terms of statistical packages for an introductory level classes is going to be flashier to the students, especially when introducing graphs and charts, but they will always ask: How are we going to be tested and on what? and the answer to that question will decide upon which method the student will accept. If the educational system permits a percentage of the total points on projects and on homework assignments, student will certainly benefit from using technology. But if the system does not (like my university system) students do not even hand-in the homework assignments. So, it is the class size and the evaluation system that encourages or discourages the use of technology as a teaching aid.

If emphasis was on meaning, many students at the introductory level in the behavioral science are not prepared for the meaning of statistics, and ended up knowing neither the theory nor the computational procedures. And the fact remains that the concepts and the logic underlying the meaning of statistics, is difficult for most students whose class room instructions follow the computational or on the meaning approaches. From my experience a mix of both approaches is more beneficial and motivates the teaching/learning process. However, when teaching at that level, students should be aware of the existence of statistical packages that do computations and computer output should be introduced and displayed. When I teach topics such as graphical presentations, analysis of variance, correlation and regression analysis to my students, I follow the traditional approach, I give the purpose, assumptions, meanings, formulas and computation method. Afterwards I display a Minitab or Excel output and explain the meanings of the output obtained in relation to what have been introduced to. When I mention to the students that it took only "data entry time" to get all that output, students asked for special sessions to learn "how" and they become really motivated by the ease of use; self- learning is stimulated and this opens doors for students to specialize in statistics and in computer programming as well.

Specialized classes for the professional (to-be) statistitians, such as experimental design, analysis of variance, sample survey design, regression, time series or multivariate analysis should take a teaching approach that well constructs concepts and builds well the learning process. Usually classes are smaller in size, and students are motivated to be a "Successful Statistics Consultant "; they expect to learn meanings, they expect to learn *why*, *when*, *what*, and *which* statistical procedure to use. They expect their statistics faculty not to spend their time in material development, but should focus in the discipline identifying those "teachable units" that can benefit from technology (Paul Velleman in McKenzie & Rao, 1999), to give them consulting experience and case studies, not "how to do" experience. Students at that level teach themselves "the how", seek to use technology on their own at home or at school, and they feel that it is much better to spend classroom time discussing the meaning of the output, the fitness/unfitness of the chosen model, and the usefulness of the method presented. The use of mathematical packages such as MATLAB (www.mathworks.com) and MATHEMATICA (www.wri.com) have eased and helped to a great deal in problem solving, however, they should not replace the traditional instructions to build the mathematical thinking.

When teaching statistics as "tools" by the non-specialists to a non-specialized class, not much is given to meanings or to the intermediate steps to reach conclusions. However, too much

of class time is spent on computations, as evident from Marketing textbooks or statistical quality control topics in most production management texts. The use of technology for such classes enhances the learning process and boosts the integration of statistics with other functions to promote active learning with less effort into doing things.

IMPACT OF TECHNOLOGY ON THE TEACHING/LEARNING PROCESS

Teaching statistics for the professionals has highly progressed on the technical, practical, and theoretical levels (Lock, 1999). On the technical level cheap and powerful computing has helped to a great extent in graphical data display, interactive methods for data description, and in new methods of inference. At the practical level the use of computers has affected the systematic assessment of fit; more effort is put into the complex process of choosing suitable models. Also, communications with the course professor via electronic mail and the creation of a course newsgroup on the web have helped the students to communicate freely and helped to diminish the feeling of anonymity students usually get.

At the theory level, technology affected two kinds of changes: (a) statistical practice has partly outgrown its mathematical theories; (b) model choosing, model checking, model free description do not fit the older theoretical framework. But, it is the job of the instructor to search out those intuitive processes and correct the incorrect ones.

Thus, the use of technology has helped the students to:

1. Learn the basic elements of statistical thinking. Concepts of probability, randomness and distributions are very difficult for students to learn but learning is enhanced when technology is used to cover these concepts where lectures are not generally effective;
2. Put emphasis on data production and data mining techniques i.e. collecting data, surveying and consolidating it, and dealing with data heterogeneity (Richard Deveaux in McKenzie & Rao, 1999), at the expense of less theory and fewer formulas, students must get their hands dirty with data (Dick Schaeffer, University of Florida);
3. Get the feel for the variability concept which is the main pillar of statistics, and lecturing alone makes it an abstract concept. The use of technology helps to explain patterns, deviations, and mathematical models for patterns and modern data dialogue (Cobb, 1997).
4. Encourage active learning by (a) less lecturing, more reading to textbooks, guided by handbook containing sample questions and sample problems, (Garfield, 1995); (b) projects, lab exercises, group problem solving and discussions, written and oral presentations; (c) have the students discuss and write about their understanding and interpretations of the problem.

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