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AUTHOR	Bliss, Leonard B.; Tashakkori, Abbas
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ABSTRACT

This paper discusses the objectives that would be appropriate for statistics classes for students who are not majoring in statistics, evaluation, or quantitative research design. These "non-majors" should be able to choose appropriate analytical methods for specific sets of data based on the research question and the nature of the data, and they should be able to interpret the results of data analyses in light of the research question that was proposed. Non-majors should be able to choose from and to interpret the results from these classes of statistical procedures: (1) descriptive statistics (measures of central tendency and measures of variations); (2) measures of relative standing; (3) measures of association (bivariate correlation and regression and multiple correlation and regression); (4) simple cases of hypothesis testing (t-tests, analysis of variance, and analysis of covariance); and (5) multivariate techniques (multivariate analysis of variance, factor analysis, discriminant function analysis, and canonical correlation and regression). Nonmajors also should be able to use statistical analysis computer packages, with the depth of learning determined by the needs of the student. (SLD)

Content-Related Issues Pertaining to Teaching Statistics:

Making Decisions About Educational Objectives in Statistics Courses

Leonard B. Bliss and Abbas Tashakkori

Florida International University

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The Task Force on Statistical Inference of the American Psychological Association's Board of Scientific Affairs (Wilkinson, 1999) and the American Statistical Association's Committee on Professional Ethics (American Statistical Association, 1999) produced recommendations that provided useful guidelines for instructors to use in the selection of content for statistics courses. While these guidelines provide some help for in choosing objectives, they provide an incomplete and somewhat limited view of the questions that need to be asked when making content decisions concerning statistics instruction. This limitation could be due to the fact that the people who are asking these questions are subject matter specialists whose primary sources of information are their own professional judgement and the professional judgement of their colleagues. The preceding remarks should in no way be interpreted to suggest that statistics subject matter specialists are incapable of asking sound, useful questions about the content of statistics courses and of answering these questions in a manner that will lead to sound decisions. What is suggested, however, is that the choice content in <u>any</u> course or series of courses is a curricular issue and that curriculum specialists have recognized the need to go beyond relying on the expertise of subject matter specialists for over half a century.

As early as the 1940s, Ralph Tyler (1949) suggested a model for curriculum development that identified four steps in the development of any curriculum. Although this model has been criticized as being overly structured and mechanistic (Darling-Hammer & Snyder, 1992) it remains a popular and respected strategy for curriculum development. The "Tylerian Rationale", as this strategy has come to be known, includes four consecutive procedures which can be described as 1) Determining educational objectives; 2) Determining learning strategies for facilitating students' reaching these objectives; 3) Ordering the learning strategies so they are most likely to facilitate students' reaching the educational objectives; and 4) Assessing the level of acquisition of these objectives after instruction has taken place. Of course, the first procedure deals with choosing the content of the instructional unit.

Tyler goes on to suggest that there are three sources where curriculum developers can inquire to find the objectives in the first procedure of the rationale. These are 1) the everyday life of the student; 2) the nature of the society in which the student lives; and 3) the opinions of subject matter specialists. The APA and ASA documents alluded to earlier are informed primarily by the opinions of subject matter specialists. While an argument can be made that the ASA ethical guidelines are a response to the nature of the society, their source is still an organization and committee made up primarily of statistics subject matter specialists. Hence, these documents are only informed by one of the three sources of objectives. The APA document particularly, when it recognizes students at all, treats them as uniform recipients of information who act in uniform ways.

Experts in pedagogy and andragogy have used the principal of individualizing instruction for literally thousands of years. The Jewish Passover Haggadah, redacted around a thousand years ago, describes the different ways one should teach the lessons of the holiday to children who are, in turn, capable, arrogant, slow in learning, and too young to ask sophisticated questions. Somewhat later, in 1916, Dewey made this notion one of the defining ideas of the Progressive movement. The idea that we must take the experiences and needs of the student into consideration when choosing objectives, and therefore content, for our courses is central to the ideas of multiculturalism and the requirement that we cope with the level of diversity evident from recent reports of census data. Of course, the everyday life of students is very complex and we could exhaust ourselves trying to deal with every particular and nuance of this life. This discussion will limit the complexity by focusing on a particular aspect everyday life experiences of university students enrolled in statistics classes. Specifically, the discussion will classify students as either majoring in programs in statistics, evaluation, and/or quantitative research design ("majors"), or majoring in some other area ("non-majors").

The literature in the teaching of statistics does not lack for discussion dealing with methods but it is remarkably thin in dealing with the issue of the appropriateness of content (Becker, 1996). This is not a surprising finding considering that the people producing this literature and making decisions about curriculum in statistics courses and programs are themselves, former majors who take the appropriateness of the content for everyone for granted. Nor does the phenomenon place the people making these decisions in a negative light. After all, they have devoted a large portion of their lives to this discipline and anything that merits that much effort must be important enough for every educated person to know. Nevertheless, it does strongly suggest a need to look at objectives that would be appropriate for non-majors taking statistics courses.

Categories of Objectives

Basically, non-majors should be able to 1) choose appropriate analytical methods for specific sets of data based on the research question and the nature of the data; and 2) interpret the results of data analysis in light of the research question which was proposed. This first category includes not only the ability to choose appropriate strategies for analyzing data when the student is a producer of research, but also the ability to evaluate the appropriateness of data analysis strategies in reports of empirical research that appear in the literature. In fact, this ability to be a knowledgeable consumer of research is conceivably the more important of the two skills for non-majors.

The ability to interpret results of data analysis is a complex set of skills that has been further complicated by the almost universal use of computerized statistical package to carry out the mathematical operations involved in the process. In fact, it is safe to say that many of our more sophisticated data analysis strategies are possible only because we have access to these machines and this software. Not unreasonably, each of these packages reports out results of analysis in a way that, while consistent throughout the package, is often different in form and/or language (including notation) from other packages. For instance, the widely used Statistical Package for the Social Sciences has, since time immemorial, reported out a value it refers to as "Significance" in all its tests of statistical inference. This estimate of the probability that the researcher would be making a Type I error if he or she were to reject the null hypothesis given the available data was referred to as "p" in BMDP and is currently reported out as "p" in SYSTAT. Interestingly, this estimate will not appear in journals using APA style tables, in any case, since the fourth edition of the Publication Manual calls for simply indicating significance levels with asterisks and prime signs after the reported values of the F statistic (American Psychological Association, 1994, p. 131). Perhaps in memory of its origins in the days of line printers, SPSS output uses only ASCI characters. As a result, SPSS output does not use the notation commonly used in statistics text books and by most statistics instructors. Students who use SPSS will see statistics labeled "Mean Difference", but never "$\overline{X}_1 - \overline{X}_2$" in their output. As if to further confuse the matter, this would show up as "$M_1 - M_2$" in a strict APA editorial style publication. At issue, is the idea of familiar versus unfamiliar forms. That is, while it may be relatively simple for students to learn to look for a particular pattern of information on a computer output and to memorize an algorithm for decision making based on this pattern, it is another and more difficult task for these same students to be able to recognize the information and make decisions using it when it is presented in an unfamiliar form. Non-majors should be able to interpret the results of statistical analysis in both familiar and unfamiliar forms.

General Content

Once it is agreed that non-majors should be able to choose appropriate analytical statistical tools for specific jobs and can interpret the information obtained from the use of these tools, it becomes necessary to define and delimit the statistical tools from which these students must choose. Non-majors should be able to choose from and to interpret the results from the following classes of statistical procedures:

I. Descriptive statistics
   A. Measures of central tendency
   B. Measures of variation
II. Measures of relative standing
III. Measures of association
   A. Bivariate correlation and regression
   B. Multiple correlation and regression
IV. Simple cases of hypothesis testing
   A. t tests
   B. Analysis of variance (one factor and factorial)
   C. Analysis of Covariance

V. Multivariate techniques

A. Multivariate analysis of variance

B. Factor analysis

C. Discriminant function analysis

D. Cononical correlation and regression

Quite clearly, these general sets of content assume within them certain more specific objectives. For instance, being able to interpret the results of statistics that are used in simple cases of hypothesis testing requires the mastering of objectives involved in understanding and applying the logic behind hypothesis testing. Where the everyday life of the student, comes into play is in determining the breadth and depth of the objectives chosen within each of these content areas. It might be helpful to conceptualize a series of "issues" which can be used as aids in thinking about depth and breadth of objectives across more one or more area of content. One useful issue for making decisions of this type is the issue of theory versus practice.

Theory Versus Practice in Objectives for the Non-major

In scientific inquiry, the role of theory is to be explanatory of a large range of phenomena. From this point of view, it is arguable whether theories even exist in statistics. Rather than get into that argument, however, let us concede that what we are usually referring to when we discuss the teaching of "theory" when we contrast it with "practice" in the teaching of statistics is really some overreaching concept that is useful across specific tools and procedures. Such a concept is "variability." Variability is a concept that is useful when we are simply looking at scores in a sample or when we are looking at the shape of a sampling distribution of means. We apply the concept when we are seeking to explain differences between sample and theoretical distributions in ANOVA and when we are describing loading in a factor analysis. The concept underlies a large portion of the procedures taught in typical statistics courses and sequences of courses. Other broad concepts include the nature of data scales, statistical significance, and power. When deciding the breadth and depth of objectives concerning these concepts in statistics courses and programs for non-majors, the curriculum developer should inquire as to what objectives are necessary if students are to be able to choose appropriate analytic methods and interpret the results of data analysis. One clear difference in the everyday lives of students taking statistics courses at the present time of those who took these same courses 30 years ago is the ubiquity and power of microcomputers and of software designed to carry out statistical analysis on these computers. This constitutes as second issue that we might look at.

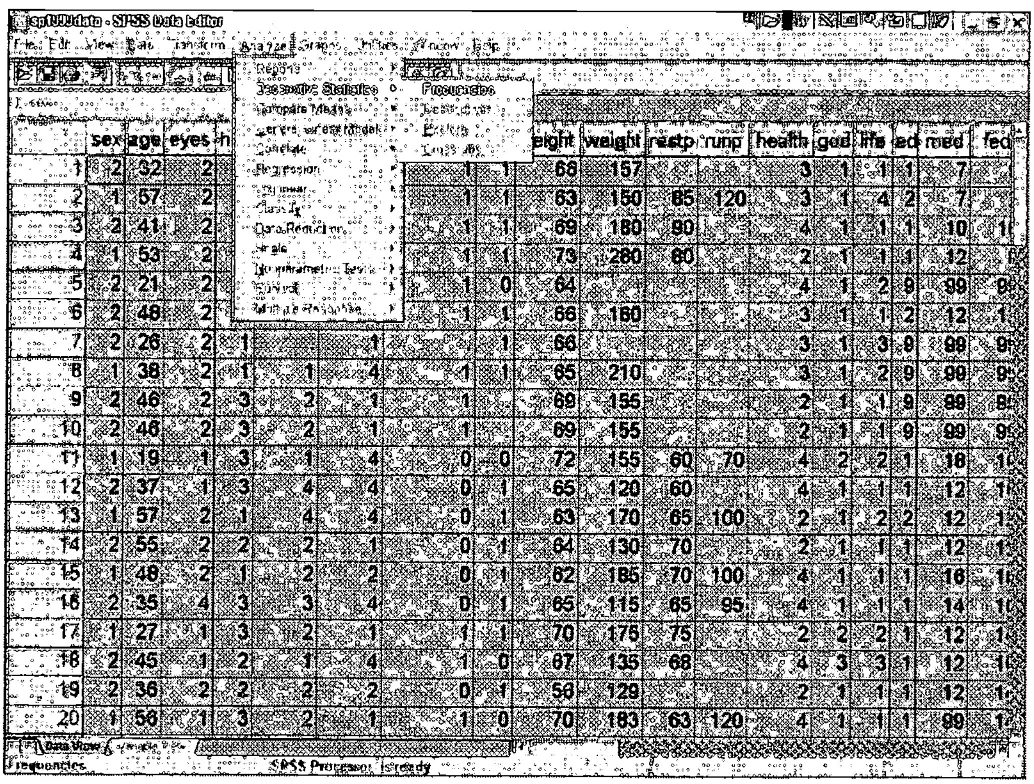
The Role of Microcomputers in Statistics Classes

Microcomputers take the computation out of statistics. That is, software is now available which will do the calculations required to carry out various statistical tests and other procedures without the user being aware of the mathematics involved in these calculations. How far the user is actually removed from the calculations, that is how much the statistical program becomes a "black box" to the user (similar to the manner in which the microcomputer itself is a black box to the typical user of microcomputers), is a function of the nature of the statistical package and of how instructors choose to present these statistical packages to students. Again, SPSS will serve as an example although SAS and MINITAB could serve equally well.

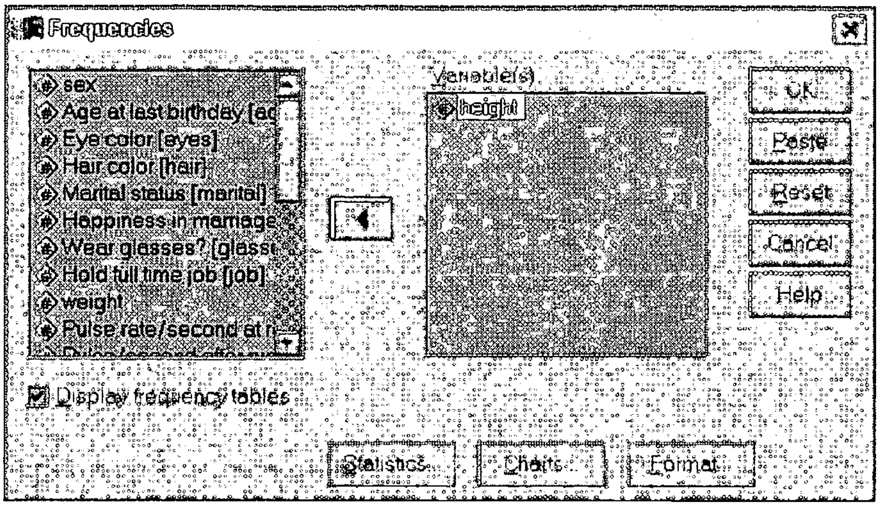
In their first incarnations computerized statistical packages required the user to issue commands on punch cards and, later, from a keyboard directly wired to the CPU. So, the command to produce a frequency distribution of values in the variable HEIGHT, find the mean and standard deviations of those heights and to draw a histogram of these values would have been:

FREQUENCIES VAR=HEIGHT/STATS=MEAN STDEV/HIST=MIN(48) MAX(96) FREQ(10).

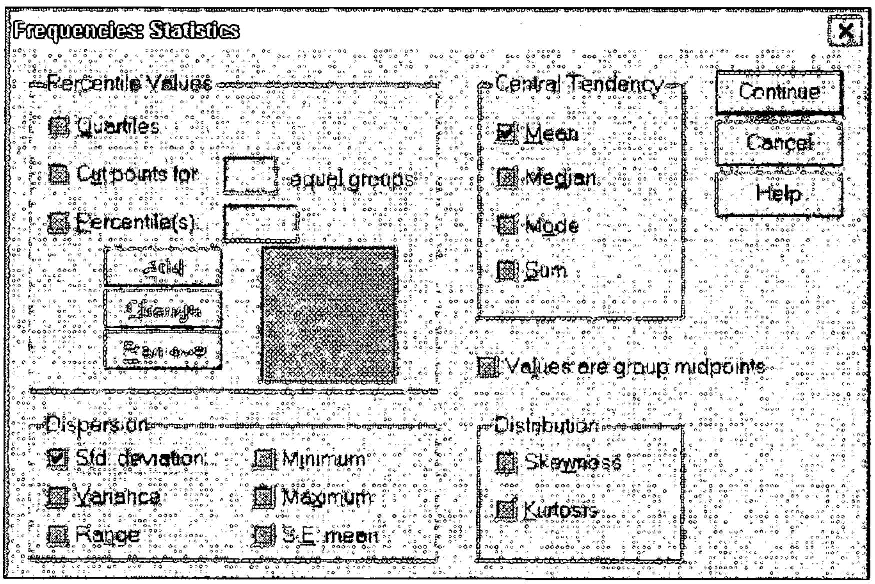
Under the more recent versions written to be used in the point and click Microsoft Windows environment the user would click on the *FREQUENCIES* choice under a *Descriptive Statistics* submenu of an *Analyze* main menu as shown below.



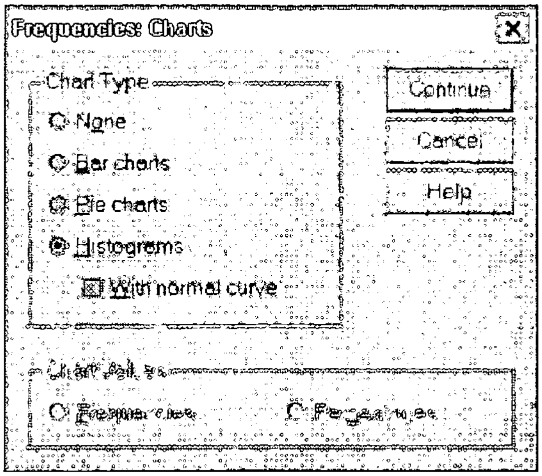
This will produce a dialog box in which the user will highlight the variable HEIGHT and move it into an active box on the right side of the window. As shown below.



Next the user would click on the statistics box and check the *Mean* and *Std. deviation* boxes to obtain these statistics before clicking on the *Continue* button to return to the main *Frequencies* dialog box as shown in the following.



Finally, the *Charts* button in the main dialog box would be clicked on giving the dialog box below to the left where the *Histogram* circle will be clicked and the *Continue* button pressed.



This procedure returns the user to the main dialog box. Note that there is no way for the user to control the minimum and maximum values used in the procedure when the WINDOWS dialog boxes are used. Nor is the user in control of the vertical axis. Clicking on the *OK* button in the main dialog box produces the same output as the line of commands shown earlier. It might be argued that the point and click of the Windows environment makes the statistical package more of a black box than does the use of command language, just as automatic transmission makes an automobile somewhat more of a black box than it was when the driver was using automatic transmission. Curriculum designers making decisions about whether it is necessary or desirable to require non-majors to learn command language syntaxes when using statistical packages will need to consider the level at which students who must be able to choose appropriate analytic methods and interpret the results of data analysis should be able to use statistical packages on microcomputers.

<u>Conclusions</u>

Clearly, these are but two of the major issues concerning breadth and depth within contents of statistics classes. Others include such issues as the appropriateness of hand calculation of various statistics and statistical tests. Related to this is the appropriateness of teaching students to use computational formulas and requiring that they be able to use these formulas in computation. The purpose of this presentation has not been to make specific recommendations concerning the depth and breadth of content in statistics courses. Rather, we have attempted to briefly describe a strategy which perceives making choices concerning content as part of a general process of curriculum development and to suggest that subject specialists in statistics look to the ideas of specialists in curriculum design within colleges and schools of education. We have suggested that the general failure of faculty teaching statistics to do this has resulted in curricula that are heavily informed by subject matter specialists, but fail to take into consideration needs of the learner and, to some extent, the nature of the society under which the learner will practice. The ASA Committee on Professional Ethics did allude to the nature of society in its report. These allusions, however, were simply general statements of ideas such as, "Effective functioning of the economy depends on the availability of reliable, timely, and properly interpreted economic data" (Preamble, Part B).

We have suggested a simple method of categorizing the everyday life of students as they approach statistics classes by noting that some of our students are majoring in statistics, evaluation techniques, and quantitative research design while others are majoring in other areas and are taking our courses in order to carry out their own research and to understand a certain portion of the literature of their fields. We designated these students as "majors" and "non-majors" and suggested that the everyday lives of these people, both as students and as professionals, should be used to make decisions concerning the breadth and depth of objectives in the various areas of statistics.

Finally, we looked at two of many issues involving the depth and breadth of content, namely "Theory Versus Practice" and "The Role of Microcomputers in Statistics Classes" and began to demonstrate how decisions could be made for non-majors.

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