Excerpt from ASA's 2016 GAISE Report for Colleges, pp8-11
http://www.amstat.org/asa/education/Guidelines-for-Assessment-and-Instruction-in-Statistics-Education-Reports.aspx

Goals for Students in Introductory Statistics Courses

The desired result of all introductory statistics courses is to produce statistically educated students, which means that students should develop the ability to think statistically.

The following goals reflect major strands in the collective thinking expressed in the statistics education literature. They summarize what a student should know and understand at the conclusion of a first course in statistics. Achieving this knowledge will require learning some statistical techniques, but mastering specific techniques is not as important as understanding the statistical concepts and principles that underlie such techniques. Therefore, we are not recommending specific topical coverage.

1. Students should become *critical consumers* of statistically-based results reported in popular media, recognizing whether reported results reasonably follow from the study and analysis conducted.
2. Students should be able to recognize questions for which the *investigative process* in statistics would be useful and should be able to answer questions using the investigative process.
3. Students should be able to produce *graphical displays and numerical summaries* and interpret what graphs do and do not reveal.
4. Students should recognize and be able to explain the central role of *variability* in the field of statistics.
5. Students should recognize and be able to explain the central role of *randomness* in designing studies and drawing conclusions.
6. Students should gain experience with how *statistical models*, including multivariable models, are used.
7. Students should demonstrate an understanding of, and ability to use, basic ideas of *statistical inference*, both hypothesis tests and interval estimation, in a variety of settings.
8. Students should be able to interpret and draw conclusions from standard output from *statistical software packages*.
9. Students should demonstrate an awareness of *ethical issues* associated with sound statistical practice.

Goal 1: Students should become *critical consumers* of statistically-based results reported in popular media, recognizing whether reported results reasonably follow from the study and analysis conducted.

To be a critical consumer of statistically-based results, it is necessary to understand the components that produced them: the design of the investigation, the data, its analysis, and its interpretation. Identifying the variables in a study, which includes consideration of the measurement units, is a necessary step to inform judgments or comparisons. Identifying the subjects (cases, observational units) of a study and the population to which the results of an analysis can be generalized helps the consumer to recognize whether the reported results can reasonably support the conclusions claimed for an analysis. Being able to interpret displays of data (tables, graphs, and visualizations) and statistical analyses also informs the consumer about the reasonableness of the claims being presented.

Goal 2: Students should be able to recognize questions for which the *investigative process* in statistics would be useful and should be able to answer questions using the investigative process.

The investigative process begins with a question that can be translated into one or more statistical questions – questions that can be investigated using data. While many questions do not have simple yes or no answers, knowing how to obtain or generate data that are relevant to the goals of a study is crucial to providing useful information that supports decision-making in the sciences, business, healthcare, law, the humanities, etc. Understanding and applying the principles of representative sampling for an observational study or designing an experiment is critical to the investigative process. Understanding and, when possible, controlling for the impact of other variables is important.

Once high quality data have been collected, meaningful graphs and numerical summaries (generally created using technology) shed light on the question under study. These summaries help to identify statistical inference procedures that are appropriate to the question. The results of the data analysis, and any limitations, need to be clearly communicated.

Goal 3: Students should be able to produce *graphical displays and numerical summaries* and interpret what these do and do not reveal.

Data analysis involves much more than constructing a confidence interval or finding a p-value. Graphical displays of data provide information on the distribution of data values, relationships among variables, and outliers. With the advent of large datasets – often from observational studies that may not be a random sample from a defined population, making standard inferential techniques inappropriate – the proper use of graphical displays is critical. Using software to produce graphical displays makes visualization of large data sets relatively easy. Important univariate graphical displays include histograms, boxplots, dotplots, and bar charts. Bivariate graphical displays include scatterplots, clustered and stacked bar charts, and comparative histograms and boxplots. Additional variables can often be added to a graphical display (for example, separately colored points and regression lines for males and females can be included in a scatterplot that relates age to height for children 3 years to 18 years).

Goal 4: Students should recognize and be able to explain the central role of *variability* in the field of statistics.

Variability is a key characteristic of data that underlies statistical associations and inference. Identifying the sources of variability in a statistical study is an important consideration. Graphical displays and numerical summaries help to illustrate and describe distributions of data (shape, center, variability, and unusual observations) and to select appropriate inference techniques. The role of sampling variability is the bridge to making comparisons and drawing inferences. At the introductory level, this includes an understanding of univariate (and perhaps bivariate) sampling distribution and/or randomization distribution models, and the role of features such as sample size, variability in the statistics, and distributional shape in these models. Understanding how results vary from sample to sample is a challenging topic for many students.

Goal 5: Students should recognize and be able to explain the central role of *randomness* in designing studies and drawing conclusions.

The mathematical understanding of "random" (*not* synonymous with haphazard or unplanned) is fundamental to the role that randomness plays in statistical studies. Distinction of probabilistic sampling techniques from non-probabilistic ones help to recognize when it is appropriate for the results of surveys and experiments to be generalized to the population from which the sample was taken. Similarly, random assignment in comparative experiments allows direct cause-and-effect conclusions to be drawn while other data collection methods usually do not.

Goal 6: Students should gain experience with how *statistical models*, including multivariable models, are used.

Understanding the role of models in statistics is a critical skill for being able to investigate the distribution of data values and the relationships between variables. The first recommendation of the GAISE report is to *teach statistical thinking*. One of the key features of statistical thinking is to understand that variables have distributions. Models help us describe the distribution of variables, especially the distribution of one or more variables conditional upon the values of one or more other variables.

It is important to understand that two variables may be associated and that statistical models can be used to assess the strength and direction of the association. Bivariate models that relate two variables – such as the regression model relating a dependent quantitative response variable to an independent quantitative explanatory variable – are building blocks for more complicated multivariable models. While the details of these more complicated models may be beyond most introductory courses, it is important that students have an appreciation that the relationship between two variables may depend on other variables. Multivariable relationships, illustrating Simpson's Paradox or investigated via multiple regression, help students discover that a two-way table or a simple regression line does not necessarily tell the entire (or even an accurate) story of the relationship between two variables.

Goal 7: Students should demonstrate an understanding of, and ability to use, basic ideas of *statistical inference*, both hypothesis tests and interval estimation, in a variety of settings.

Statistical inference involves drawing conclusions about a population from the information contained in a sample. Often this involves calculation of sample statistics to make inferences about population parameters either through estimation (for example, a confidence interval to estimate the proportion of voters who have a favorable impression of the President of the United States) or testing (for example, a hypothesis test to determine if the mean time to headache relief is less for a new drug than a current drug). At least as important as calculating confidence intervals and *p*-values is understanding the concepts underlying statistical inference. Understanding the limitations of inferential procedures, including checking assumptions, and the effect of sample size and other factors, are important to assessing the practical significance of results and that if you conduct multiple tests, some results might be significant just by chance. Being able to identify which inferential methods are appropriate for common one-sample and two-sample parameter problems helps develop statistical thinking skills. Providing ample opportunity to practice drawing and communicating appropriate conclusions from inferential procedures allows students to demonstrate understanding of statistical inference.

Goal 8: Students should be able to interpret and draw conclusions from standard output from *statistical software*.

Modern data analysis involves the use of statistical software to store and analyze (potentially large) datasets. While there may be value to performing some calculations by hand, it is unrealistic to analyze data without the aid of software for all but the smallest datasets. At a minimum, students should interpret output from software. Ideally, students should be given numerous opportunities to analyze data with the best available technology (preferably, statistical software).

Goal 9: Students should demonstrate an awareness of *ethical issues* associated with sound statistical practice.

As data collection becomes more ubiquitous, the potential misuse of statistics becomes more prevalent. Application of proper data collection principles, including human subjects review and the importance of informed consent, are central to the effective and ethical use of statistical methods. Relying on statistical methods to inform decisions should not be confused with abusing data to justify foregone conclusions. With large datasets containing many variables, especially from observational studies, understanding of confounding and multiple testing false positive rates becomes even more relevant.