Revising the Undergraduate Major in STATISTICS

It has been more than a decade since the American Statistical Association (ASA) approved a set of curriculum guidelines (*www.amstat.org/education/curriculumguidelines.cfm*) for undergraduate statistics programs (approved 2000). Since that time, much has changed. The "Age of Big Data" arrived. Interest in the AP Statistics program flourished. The number of people receiving undergraduate degrees in statistics increased dramatically. New tools became available for statisticians. It is a good time to rethink the undergraduate curriculum.

President-elect Nathaniel Schenker has appointed a working group consist¬ing of representatives from academia, industry, and government to make recommendations for changes in the guidelines.

The working group welcomes your input. In addition to the survey form on the website, we are hosting a series of webinars this fall including discussions of large programs, community colleges, data science/big data, and the role of capstones. Information about participating in the live webinars or viewing the recorded webinars is available at *www.amstat.org/education/curriculumguidelines.cfm.*

Feedback also can be sent to the working group chair, Nicholas Horton, at *nhorton@amherst.edu*.

ASA
AMERICAN STATISTICAL ASSOCIATION
Promoting the Practice and Profession of Statistics™

Curriculum Guidelines for Undergraduate Programs in Statistical Science (approved 2000)

The American Statistical Association endorses the value of undergraduate programs in statistical science for both statistical science majors and students in other majors seeking a minor or concentration. Following are guidelines for development of curricula for such programs.

Principles

Undergraduate programs in statistics are intended to equip students with quantitative skills that they can employ and build on in flexible ways. Some students will plan graduate work in statistics or other fields, while others will seek employment after their first degree. Programs should be sufficiently flexible to accommodate varying goals. Undergraduate programs are not intended to train professional statisticians, though some graduates may reach this level through work experience and/or further study.

Institutions vary in the type and intensity of programs they offer. The ASA believes almost all institutions can provide a level of statistical education that is useful to both students and employers. We encourage flexibility in adapting these guidelines to institutional constraints. In many cases, statistics minors or concentrations for quantitatively oriented students in fields such as biology, business, and behavioral and social science may be more feasible than a full statistics major.

Undergraduate statistics programs should emphasize concepts and tools for working with data and provide experience in designing data collection and analyzing real data that goes beyond a first course in statistical methods. The detailed statistical content may vary and be accompanied by varying levels of study in computing, mathematics, and a field of application.

Though statistics requires mathematics for the development of its underlying theory, statistics is distinct from mathematics and uses many non-mathematical skills; thus, the curriculum must be more than a sequence of mathematics courses. It is essential that faculty trained in statistics and experienced in working with data be involved in developing statistics programs and teaching or supervising courses required by the programs.

Skills Needed

Effective statisticians at any level display a combination of skills that are not exclusively mathematical. Programs should provide background in the following areas:

Statistical - Graduates should have training and experience in statistical reasoning, design of studies (including practical aspects), exploratory analysis of data by graphical and other means, and a variety of formal inference procedures.

Mathematical - Undergraduate major programs should include study of probability and statistical theory, along with the prerequisite mathematics, especially calculus and linear algebra. Programs for nonmajors may require less study of mathematics. Programs preparing for graduate work may require additional mathematics.

Computational - Working with data requires more than basic computing skills. Programs should require familiarity with a standard statistical software package and encourage study of data management and algorithmic problemsolving.

Non-mathematical - Graduates should be expected to write clearly and speak fluently. They also should have developed skills in collaboration, teamwork, and organizing and managing projects.

Substantive area - Because statistics is a methodological discipline, statistics programs should include some depth in an area of application.

Curriculum Topics for Undergraduate Degrees in Statistical Science

The approach to teaching the following topics should:

1. Emphasize real data and authentic applications
2. Present data in a context that is both meaningful to students and indicative of the science behind the data
3. Include experience with statistical computing
4. Encourage synthesis of theory, methods, and applications
5. Offer frequent opportunities to develop communication skills

Statistical Topics

1. Statistical theory (e.g., distributions of random variables, point and interval estimation, hypothesis testing, Bayesian methods)
2. Graphical data analysis methods
3. Statistical modeling (e.g., simple, multiple, and logistic regression; categorical data; diagnostics; data mining)
4. Design of studies (e.g., random assignment, replication, blocking, analysis of variance, fixed and random effects, diagnostics in experiments; random sampling, stratification in sample surveys; data exploration in observational studies)

Mathematical Topics

1. Calculus (integration and differentiation) through multivariable calculus
2. Applied linear algebra (emphasis on matrix manipulations, linear transformations, projections in Euclidean space, eigenvalue/eigenvector decomposition, and singular-value decomposition)

Probability

1. Emphasis on connections between concepts and their applications in statistics

Computational Topics

1. Programming concepts; database concepts and technology
2. Professional statistical software appropriate for a variety of tasks

Non-mathematical Topics

1. Effective technical writing and presentation
2. Teamwork and collaboration
3. Planning for data collection
4. Data management

Electives - There are many electives that might be included in a statistics major. As resources will vary among institutions, the identification of what will be offered is left to the discretion of individual units.

Practice - When possible, the undergraduate experience should include an internship, senior-level "capstone" course, consulting experience, or a combination. These and other opportunities to practice statistics should be included in a variety of venues in an undergraduate program.

Curriculum Topics for Minors or Concentrations in Statistical Science

The core of a minor or concentration in statistics should consist of the following:

- General statistical methodology (statistical thinking, descriptive, estimation, testing, etc.)
- Statistical modeling (simple and multiple regression, diagnostics, etc.)
- Exposure to professional statistical software

The number of credit hours for minors or concentrations will depend on the policies set by the academic units involved. Additional topics to complete the required number of credit hours could be chosen from a nonexhaustive list (e.g., mathematical statistics, design of experiments, categorical data analysis, time series, Bayesian methods, probability, database management, a capstone experience). Courses from other departments with significant statistical content might be allowed to count toward a statistics minor or concentration, though the content of such courses must differ substantially.