Advice from Prospective Employers on Training BS Statisticians

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Robert V. Hogg, Ph. D.
Mary Ann Ritter
Robert Starbuck, Ph.D.

"Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write."
H. G. Wells[1]

Introduction

The time envisioned by H. G. Wells has arrived. Statistical thinking is a necessity for educated citizens. Educational institutions, especially liberal arts institutions, have been rethinking their curriculums and the need for teaching statistical and quantitative thinking skills.

The American Statistical Association has initiated work to prepare a set of recommendations for undergraduate education in statistics, both for undergraduate statistics majors and for the statistics component of other degree programs. A three-stage effort began in May of 1999, with a small group of statisticians who met at ASA headquarters in Alexandria, Virginia. They planned to develop a set of short discussion papers on the important issues in statistics education; these papers would then form the basis of a larger symposium to be held in conjunction with the Joint Statistical Meetings in August 2000.

This paper summarizing advice from prospective employers of BS statisticians is one of the workshop papers. The purpose of this paper is threefold:

(1) To provide input to the design of BS-Statistics degree program requirements,
(2) To give information useful for the career and academic counseling of BS-Statistics students and
(3) To offer assistance to students considering statistics as an undergraduate major.

This paper refers to BS-Statisticians. By this we mean both undergraduates majoring in statistics and undergraduates in other majors who study statistics with the aim of using statistics to improve their immediate employability following graduation.

The statisticians who contributed to this paper are not academicians—they are employed by business, industry, consulting and pharmaceutical firms and government. The advice in this paper is aimed at preparing students for non-academic employment using their training in statistics and it is based on the contributing statisticians' own observations and experiences.

Background

Statistics degrees are widely thought of as professional degrees with an emphasis on graduate rather than bachelors' degrees. Statistics Ph.D. holders have well-recognized career opportunities in academia, government and industry. MS-Statistics degrees are understood to be appropriate preparation for careers in government and industry, although not usually for university teaching positions. However, a surprisingly large number of BS-Statistics degrees currently are awarded each year to individuals, many of whom do not pursue graduate study immediately.

Table 1 below lists the universities that granted ten or more degrees in 1996-1997, the last year for which data are available. These twelve institutions together graduated 231 BS-Statisticians. Fifty-one other institutions granted an additional 244 BS-Statistics degrees for a total of 575. During the same period 1490

master's degrees in statistics were granted. It is interesting, and surprising to some, that the BS-Statistics degrees (575) were 39% of the MS-Statistics degrees.

Table 1

Institutions Granting BS Degrees in Statistics
1996-1997 Data

INSTITUTION	NO. DEGREES GRANTED
Brigham Young University	45
North Carolina State University	24
Rutgers University	21
University of Florida	20
University of Georgia	18
State University of New York-Buffalo	17
Cornell University	17
New York University	15
Iowa State University	12
University of North Florida	12
California Polytechnic Institute	10
Johns Hopkins University	10
University of Nebraska-Lincoln	10
Subtotal	231
Institutions granting fewer than 10	244
Total	575

Source: Robert Starbuck, Ph. D., "Schools Offering Degrees in Statistics in the U.S. – 1996-1997 Data," American Statistical Association, 1999.

Data for some schools are from prior years when 1996-1997 data were unavailable.

Individuals receiving these degrees have several options at the end of their undergraduate studies—they may go on to further academic study, seek immediate employment, start their own businesses or they may attend professional school, such as medical or law school. Each of these options requires further decision and definition. For example, continuing academic study might mean continuing statistics education or a change to another field, such as operations research; it might mean an additional year of study for a masters degree or four or more additional years for a Ph.D.

Making these decisions and the ones leading up to them requires information. This paper is intended to provide such information, especially for students who will follow the path to immediate employment upon graduation.

Methods

The three authors were the participants in the May 1999 meeting who were charged with the task of writing this paper. Contributions were solicited from a group of non-academic statisticians who could comment on the employment of BS-Statisticians. Eight individuals contributed ideas, data and comments to this paper, although any errors or lack of clarity are the responsibility of the authors. The contributors and authors combine to bring experience and opinions from manufacturing, engineering, quality, pharmaceuticals, government and consulting.

The contributors were asked to respond to six questions about positions in their organizations that could be filled by recent BS-Statistics graduates:

(1) Position titles
(2) Key job elements
(3) Candidate qualifications
(4) Detailed qualifications
(5) Rating of qualifications
(6) Advice or recommendations.

Their responses were distilled and combined by the authors. The contributors were then asked to comment directly on the summary of their comments presented in a draft of this paper.

This approach provides opinion evidence from a small number of people rather than a formal survey based on a large sample. It is intended to provide a thought-provoking starting point for discussion and debate, rather than a precise catalogue of final conclusions. While the information offered represents opinions, these are the opinions of sympathetic, thoughtful people with wide experience in the area. The surprising agreement among the contributors lends further weight to their comments.

Positions for BS-Statisticians

There are very few positions exclusively for BS-Statisticians. More common are positions for which BS-Statisticians qualify, but for which statistics is only one of several appropriate types of preparation. The position titles mentioned by the contributing group were most often "statistician" modified by an adjective describing the field of work. The positions described in the Department of Agriculture were GS-5($23,000) and GS-07($28,000). Some of these titles (both industry and government) were

statistician
bio-statistician
agricultural statistician,
survey statistician
mathematical statistician and
automated data processing statistician.

Other positions mentioned included

staff (in a consulting organization) and
programmer.

Major Job Responsibilities

The major responsibilities are those which employers list when they describe jobs—these listings might appear at job fairs, on-campus employment office notices, in newspaper advertisements, in company brochures or in the formal personnel files. Many employers use terms in a special way inside their company or within an industry. To find the best employment opportunity students (and their counselors) should understand the specific responsibilities as employers term them. In addition they should learn what is meant specifically by the responsibility in a job posting. For example, if the job posting reads "responsible for programming PCs," does this mean programming personal computers in an office environment or programmable controllers on the shop floor? Or does it mean responding to problem communications from vendors?

The job responsibilities identified by the contributors are divided into three categories below. "Statistical" refers to specific theory or methods; "technical" refers to mathematical, engineering or computer-related activities and "non-statistical" refers to activities outside statistics methods and theory coursework. The most common job responsibilities were

STATISTICAL
Apply statistical methods
Apply statistical theory
Collect, analyze, interpret data
Perform general statistical consulting

Review and diagram processes
Prepare sampling frames
Draw samples

TECHNICAL
Write SAS computer programs
Use databases
Conduct web-based searches

NON-STATISTICAL
Write reports
Make presentations
Participate in teams

Formal Candidate Qualifications

Formal candidate qualifications are those characteristics that an employer states explicitly as necessary for employment. They may be required or preferred characteristics. They are usually stated in general terms. In conversation, employers produce a more detailed, meaningful description of the type of individual being sought.

The formal qualifications mentioned by the paper contributors include

(1) BS with 2 to 4 years experience
(2) BS with major in mathematics, statistics or operations research
(3) MS strongly preferred (zero to 2 years experience) seen as the equivalent of BS with 2 to 4 years experience
(4) Minor in field of application or minor in science, engineering or social science.
(5) Specific statistics course work (described below)
(6) Communication skills (written and oral)
(7) Programming skills (described below)

At this level of candidate description there was surprising agreement among the contributors despite the diversity of their experience. Almost all mentioned that a BS-statistics degree was either one of many degrees that would be considered or was the minimum qualification, with graduate study and/or graduate degree being preferred. In addition, knowledge of the subject area was considered highly desirable, although the appropriate subject matter varied with the industry or employer.

Required Competencies

Perhaps a more interesting list of qualifications is what we are calling "required competencies." These are the skills, knowledge and experience sought by employers. The Department of Agriculture referred to these as "KSAs: knowledge, skills, abilities." Sometimes the required competencies are well and fully described in the formal candidate qualifications list. More often than not, the required competencies go well beyond the formal qualifications and include statistical , technical and non-statistical competencies. These are what employers are really looking for; they may also form the basis for an employer's in-house training or continuing education programs. Sometimes the difference between the formal list and the real list is only the difference between a summary and detailed description. At other times, the difference is based on the difficulty of articulating the real need because of complexity, uniqueness or uncertainty.

The list below gives the detailed competencies behind the candidate qualifications listed above. There is a greater divergence of opinion, in part due to individuals in different types of work calling on different statistical methods. Whereas the items on the qualifications list (above) were mentioned by virtually every contributor, the following list of competencies includes items if they were mentioned by more than one contributor. The unique items are mentioned in the "One of a Kind Responses" section at the end.

STATISTICAL
Analysis of variance/general linear models
Simple analysis methods
Reliability statistics
Survival statistics
Variance component analysis
Variance propagation
Acceptance sampling
Exponentially-weighted moving average
Design of experiments
Non-standard experimental designs
Graphical analysis (box and whiskers, etc.)
Statistical process control
Sampling
Principles of statistics
Survey methods and techniques
Research methods and techniques
Data collection/handling
Limitations of methods
Statistical experience/hands on work

TECHNICAL
Tolerancing
Measurement capability analysis
Calibration
Statistical package (multiple mentions: SAS)
Database programming/database structure/large database experience
Mathematics including advanced calculus, linear algebra
Subject matter knowledge

NON-STATISTICAL
Organize work
Consulting (practical experience preferred)
Meeting participation (agendas, minutes, etc.)
Team membership/collaboration
Interpretation of statistics to non-statisticians
Communicate orally/influencing skill
Communicate in writing
Energy
Curiosity/willingness to learn/inquiring mind
Structured problem solving
Flow charting/process description

ONE-OF-A-KIND RESPONSES
S+/Minitab
Advanced mathematics including differential calculus, theory of equations, vector analysis, advanced algebra, mathematical logic, differential equations
Numerical analysis (desired by one who does not regularly hire BS-Statisticians except perhaps as SAS programmers)
Text recommended: Cleveland's *Data Visualization*
Broad, solid base of statistical course work
Categorical data and binomial methods
Willingness to relocate (government service hiring for a national program)

Relative Importance

The contributors were given the opportunity to rate the desired competencies on a scale from 1 to 5, with 5 being most important. A rating of 1 represented a skill or ability that would be useful but not required to perform satisfactorily in the position. A rating of 5 meant an essential skill without which assignments could not be completed.

A pattern emerged from the ratings: each respondent had a principal method of particular usefulness for his or her work. This method usually received the highest rating given by the individual (usually 4 or 5). An equal or almost equal rating was often given to communication skills, where both written and oral received almost exactly the same rating. In the one instance where general statistics skills were required, the rating of communication skills was the highest one given (5). Almost all of the competencies mentioned were given ratings of 3 or better, so for the most part people were mentioning competencies of real use in success on the job.

One issue for those training BS-Statisticians is the extent to which they feel responsible for guiding and or training students in non-statistical areas. One theme that is clear among the contributors is the importance of non-statistical skills for success on the job, especially communication skills. However it is to be acquired, the ability to communicate effectively seems to be as important as knowledge of the principal statistical methods of a given field. A BS-Statistician may not be considered to be suitably prepared for employment after the degree without the ability to convey what he or she knows to others in the work place.

Advice to Educators

What follows is a list of recommendations that follow from the previous discussion for the consideration of educators as they plan what and how to teach statistics to their undergraduate students.

1. Statistics is primarily an applied discipline—students should have the experience of applying their learning in settings as real as possible during their education. This could include co-ops, summer jobs, class projects, on-campus consulting centers or undergraduate research programs. This should include as much of the life of a project as possible—project planning, team consensus formulation, data acquisition and data display/interpretation.
2. Statistics should be learned in the context of one or more science, engineering or social science fields in which it might be applied. Students should be encouraged to have a minor course of study in one of the fields and to relate the statistics preparation to it via project participation, summer employment, etc.
3. Statistics is a team sport, not a cubicle-based activity. Students should learn how to participate effectively in teams.
4. Excellent oral and written communication skill development should be a core part of a statistics program.
5. Students should be taught to learn and to leave their undergraduate institution with the understanding that they must continue to learn to have a successful career with statistics. Their learning need not be part of a formal degree program, although graduate degrees in statistics will likely continue to open doors beyond the reach of a BS-statistician.
6. Students should develop the ability to use a statistical package and a programming language. SAS is recommended for consideration because of its seeming widespread use.
7. Applied statistics depends on data. Students should be able to evaluate critically the data collection process. In addition, students should become familiar with database terminology, construction and management. Facility in a database program and the practices for good database management in a data-sharing environment and for large databases should be developed.
8. Graphical methods can be the sole means of displaying analysis results in an industrial setting. Students should learn to think and explain in graphical terms.

This advice does not differ significantly from suggestions by previous authors on this subject. What may be different is the increased emphasis on computing and database skills and the very heavy emphasis that we are placing on the need for real-world experience and the non-statistical skills of communication and

group participation. Without these tools in their kit, BS-Statisticians will not be prepared, regardless of the field in which they seek employment.

H. G. Wells was correct in two ways—statistical knowledge has become important for good citizenship and the ability to read and write have continued to be important. One has not replaced the other.

Summary

Statistics and statistical thinking have become necessities for efficient citizenship. However, the BS-Statistics is a degree that has received relatively little emphasis compared to statistics graduate degrees. It is widely under-valued and has the potential for greater visibility and contribution. We hope that the ideas in this paper are thought provoking and useful to the academic community and to educators in their work as they revise and enhance the undergraduate statistics curriculum.

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[1] National Science Board, *Overview, Science and Engineering Indicators*, 1998.

Appendix A

Contributors

Rich Allen
Government
National Agricultural Statistics Service, USDA

Walter D. Flom, Ph. D.
Manufacturing
Intel Corporation

Berton H. Gunter
Pharmaceutical basic research
Merck and Company

Ronald L. Iman, Ph. D.
Consulting
Southwest Technology Consultants

Norb L. Keller
Quality
Delphi Automotive

David R. Morgenstern, Ph. D
Consulting
Westat

Jeri M. Mulrow
Consulting
Ernst & Young

Harold E. Sargent, Ph. D
Pharmaceutical
Baxter Healthcare Corporation