

**Statistics in
Business, Finance,
Management and
Information Technology:
A Layered Introduction
with EXCEL & WORD**

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Dedication

*To my beloved wife, Deborah Naomi Black
light of my life;*

*and in gratitude to the professors
whose devotion to clarity in teaching statistics
set me on a life-long course of enthusiasm
for the subject:*

*Professor Hugh Tyson,
formerly of McGill University,*

and

*Professors Robert R. Sokal z"l (deceased), and F. James Rohlf,
both of State University of New York at Stony Brook,
authors of the classic 1969 textbook,*

***Biometry, The Principles and Practice of Statistics in
Biological Research,***
now in its Fourth Edition (2012).

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Preface

I hope that students will enjoy their introduction to applied statistics. To that end, the course and this text are designed with learning in mind. The unusual layered approach is the expression of my almost 50 years of teaching (I started in 1963): instead of drowning students in increasingly bewildering detail for each topic, I want to show them comprehensible, manageable chunks of practical, useful concepts and techniques and then come back to what they have already started to learn to fill in additional details once they have built a framework for easier comprehension of subtleties.

Background

Students and teachers may be interested in knowing how a professor of information systems and information assurance also came to be a fanatic about applied statistics. If not, just skip to the next section!

In 1969, when I was a student in the Department of Biological Sciences at McGill University in Montreal, Canada, Dr Hugh Tyson taught an introduction to biostatistics using the first edition of Robert R. Sokal and F. James Rohlf's *Biometry* text. The course thrilled me. I use the verb deliberately: it struck a deep chord of delight that combined my love of biology with my life-long enthusiasm for mathematics. I had completed high school math by the age of nine and taught seniors in my high school matriculation math by the age of 13; they used to call me "Slide Rule" because I carried one on my belt. My master's thesis was a statistical analysis of extensive data collected by my research director, Dr Daphne Trasler, a renowned teratologist in the Human Genetics Sector at McGill University, about the developmental variability of inbred mouse strains and of their hybrids.

At Dartmouth College, I was admitted to the doctoral program because I helped a world-famous invertebrate zoologist apply appropriate analytical methods to frequency data, resulting in accurate estimates of the probability of the null hypotheses. Because of my knowledge of statistics, I was granted a full four-year waiver of tuition and was paid generously through the program as a Teaching Assistant and then Research Assistant, finally being given permission to teach an informal graduate seminar on applied statistics to my fellow graduate students. I served as a statistical consultant to several professors for their experimental design and data analysis. My PhD oral field exam was in applied statistics and invertebrate zoology. After my thesis was accepted in August 1976, I was hired by the Canadian International Development Agency in October 1976 to teach three levels of applied statistics in the Faculty of Social and Economic Sciences at the National University of Rwanda (in French, my native language); I was delighted to be asked by the Faculty of Agronomy also to teach a course on field experiment design and by the Faculty of Science to teach FORTRAN programming. On my return from Africa in 1978, I then taught biostatistics and some biology courses at the University of Moncton (also in French) for a year.

Although I began programming in 1965 as a kid, my first formal job in the computer science field was as a programming statistician: I was hired in 1979 (thanks to a recommendation from a friend I had known in graduate school) to define and parse the statistical syntax for INPROSYS, the compiler for a new fourth-generation language and relational-database system, and to write code generator for that syntax.

All through my career since then, I have served as a statistical consultant to colleagues and especially for my wife, Dr Deborah N. Black, MDCM, FRCP(C), FANPA, who has graciously named me as coauthor for many of her papers. At the National Computer Security Association, where I served as Director of Education between 1991 and 1999, I was also responsible for ensuring the survey design and statistical rigor of several of our annual virus-prevalence surveys.

At Norwich University, I was delighted to substitute-teach the QM370 *Quantitative Methods for Marketing & Finance* course in Spring 2002 for a professor on sabbatical and then to be offered the chance to teach QM213 *Business and Economic Statistics I* in Spring 2010. With the support of the Directors of the School of Business and Management, I hope to continue teaching QM213 until I retire on June 30, 2020!

Students: knowing statistics in addition to your main focus of study well REALLY HELPS YOU in your career! Take this course seriously!

Why a “Layered” Introduction?

In my experience of teaching statistics, I have found that textbooks are often designed as if they were reference books. They dive into depth on every topic in turn, bewildering, exhausting, and dispiriting students, who get lost in detail without grasping why the material should matter to them in their academic or professional work.

Teaching style should avoid overload and should motivate interest, giving students the opportunity to form a network of firm associations among concepts and new vocabulary before plunging into sophisticated detail. Nothing except conservatism and tradition – or, in the words of Monty Python’s *Architect Skit*, “blinkered, Philistine pig-ignorance”² stops us from introducing interesting and valuable concepts and techniques and then returning for deeper analysis and knowledge once students have begun building their own conceptual and experiential framework.

In addition, *forward references* to subjects that will be explored later in the course are valuable to students as a basis for forming increasingly complex neural networks that facilitate absorption of details later in their studies. For example, getting students used to the names and applications of analysis of variance, regression, non-parametric statistics, and other topics helps them when they plunge into the details, computations and interpretations of these methods. Instead of having to assimilate everything at once – the existence of the method, its name, its application, its computation, and its interpretation – the students have an Aha! experience as they reach the section about something they’ve heard about several times before.

This text, when it is completed will provide several layers or sweeps:

- Layer I: Getting Started – One-semester Introductory Course – this version of the text
Introduces practical, easy concepts and techniques using Excel for
 - Summarizing numerical information understandably and professionally in tables and graphs
 - Distinguishing between samples and populations
 - Estimating population parameters based on sample statistics and appropriate statistical probability distributions
 - Framing null and alternative hypotheses for statistical testing
 - Calculating and using probability of the null hypothesis as a basis for statistical decisions
 - Evaluating the strength of possible relationships among variables using
 - Goodness-of-fit tests and tests of independence using chi-square
 - Simple analysis of variance (ANOVA)
 - Correlation
 - Linear regression

I plan to expand the book over the next several years to support the next course in Quantitative Methods, QM370. Future components under consideration for the upper-year textbook include:

- Layer II: Refining Your Skills – Part 1 of Second-Level Course
Goes back to the beginning and uses case studies from the published literature to help students take more control over
 - Measuring and counting: data acquisition using metrics and surveys
 - Showing and summarizing: more complex graphics
 - Assumptions of parametric statistics: randomness, independence, homoscedasticity, normality, additivity (no interaction)
 - Data transformations: log, square root, arcsine

² < <http://www.youtube.com/watch?v=e2PyeXRwhCE> >

- Non-parametric methods
- Inference: distinguishing between association & causality in published reports
- Layer III: Additional Elegance – Part 2 of Second-Level Course
 - More sophisticated methods and more advanced topics using advanced tools such as MiniTab or SPSS:*
 - Populations, samples, confounded variables and a posteriori testing
 - Specialized probability distributions including binomial, hypergeometric, and Poisson and their applications in statistical methods
 - Log-likelihood (G) ratio for independence in multidimensional contingency tables
 - Nested ANOVA
 - Two-factor ANOVA and introduction to interaction terms
 - Multi-way ANOVA and analyzing interactions
 - Multi-way G-tests for nested and multidimensional contingency tables
 - Multiple linear regression
 - Curvilinear regression
 - Factor analysis
- Layer IV: Introduction to Experimental and Survey design – Part 3 of Second-Level Course
 - Introduction to exploratory data analysis
 - Moving averages for time series
 - Partial correlation coefficients in examinations and surveys
 - Multiple comparisons in ANOVA
 - Simple meta-analysis using published p-values and the log-likelihood function
 - Exploratory data analysis including Monte Carlo simulation
 - Estimating appropriate sample sizes
 - Control groups and double-blind studies
 - Qualitative Data
 - Surveys
 - Focus Groups
 - Computer-Aided Consensus™
 - Interviews
 - Analytical methods for qualitative data
 - Computer-Aided Thematic Analysis™

Students in Norwich University's QM213 Business & Economic Statistics are using only part 1. Any student preferring to use a paper copy instead of or in addition to the electronic version is welcome to ask for one and I'll print it at no cost to them thanks to the kindness of the University administration.

Organization of the Text

Early versions of the text used complex multilevel labels such as 1.2.1.3.1.4. Several students complained with justification that it was hard to keep track of so many levels and that the relationship between the text and the course assignments was often unclear. In response, I have reorganized the text into main sections corresponding to the weeks available in the semester at Norwich University – 14 weeks in all (the last, truncated week is used for review and exam preparation). Rather than try to show logical relationships by nesting labels, I have simply numbered all the sections within a logical block of work using the second-level labels (1.1., 1.2., 1.3....).

Instant Tests

Following up on a suggestion from QM213 student Dejan Dejan, who took the course in Fall 2010, I have inserted boxes with a few review questions throughout the early part of the text. Most of the questions are conceptual; some suggest little real-world research tasks for posting in the NUoodle classroom discussions; some have computational exercises. There are no answers posted in the book, requiring students to compare notes with each other – a Good Thing. If students are stumped they should review the text, discuss the questions with fellow-students, and ask the professor for help. And students should note that suggestions for improvement are always welcome!

The Importance of Homework

Reading about methods is too abstract to grip students emotionally or to solidify the engrams (memory traces) that underlie learning. Practical application of these techniques using interesting cases stimulates the imagination and builds neural patterns that make it easier to learn new statistical concepts and techniques.

Combining practice with repeated exposure to concepts through a layered approach to teaching helps students convert short-term memory into long-term knowledge. In my statistics courses over more than 30 years of experience, I have always assigned half or more of the final grade to homework.

Remember: reading about statistics must surely be the most passionately interesting and absorbing activity in your life right now 😊 but the only way to be good at statistics – and to pass this course – is to *do the homework*.

A practical problem arose: with 70 students in a statistics course and each one doing half-a-dozen problems per week, how can one professor grade the homework?

- Trying to grade all the results myself proved impossible – it took longer than a week to grade a single week's work.
- In the next statistics class, I tried having the students grade their own homework in class – and ended up spending one day out of three just doing the grading!
- In the next course sessions, I tried having the students do the homework and then answer questions about the specific values in particular aspects of their work. However, another problem developed in the Fall 2011 and Spring 2012 sessions of QM213, when I succumbed to an excess of sympathy for the piteous pleas of the students and allowed them to try randomized quizzes and homework assignments up to three times, taking the best of the results for each student. Unfortunately, some students were gaming the system by recording the correct answers supplied by the NUoodle system and using the lists of correct inputs to improve their scores without actually studying or doing homework at all. Students can thank those who chose to cheat instead of to study for the reduction of homework and quiz assignments to a single try.
- In addition, thanks to a student in one class who claimed to have completed all the homework despite evidence from the NUoodle log files that he never even logged into the NUoodle group between mid-February and early May, I am requiring that a selection of homework files be uploaded upon completion to provide an augmented audit trail.

Finally, several students and I quickly realized that in this course, falling behind can have disastrous consequences: what should be an easy extension of concepts and techniques mastered earlier becomes a morass of increasingly incomprehensible gibberish.

The solution starting in QM213 for the Fall of 2012 is to assign the readings and homework at the start of each week using the NUoodle online learning system to test each student on the material by the end of every week. Tests and homework assignments are due no later than the end of the Sunday of the week where they are assigned. In 2013, I began providing pre-tests with a few simple questions to be taken before Monday morning as an additional encouragement for students to at least scan their assigned readings before coming to class.

To help students who are having trouble grasping the concepts or mastering the techniques, I am providing compensatory (replacement) homework and exams that allow students to improve their scores by replacing the earlier bad scores by the later better (we hope) scores to demonstrate improvements. These replacement

homework assignments and replacement quizzes are opened a few weeks after the initial assignments so students having a hard time can ask for help.

As always in my courses, I support the work of the Academic Achievement Center (AAC) at our University and provide “a” versions of all quizzes and grading with twice the usual time allowance. One learning-disabled student actually came 1st in his class. I don’t care whether you learn fast or slow: I just want to support your learning, no matter what!

Finally, throughout this book and the corresponding course, I introduce topics only because **they make a difference in practical applications of statistics**. As I always say, REALITY TRUMPS THEORY. There is no content presented “because it’s good for you” or “because I had to study this decades ago and therefore I’m going to force you to learn it too even though it makes no difference to anyone today.” You will note that I do *not* ask you to memorize algebraic formulas; when formulas are presented they are for explanatory purposes. This is not a math course, and you will never be asked to memorize derivations of formulas. And you absolutely will not look up statistical critical values in outdated tables: almost all the statistical functions needed for a basic level of applied statistics are available in statistical packages and in EXCEL 2007, 2010, 2013 and 2016 in particular. Mac users must install their own version of the statistical analysis pack or simply use the Windows version of EXCEL available on any University computer.

Color vs Black-and-White

This textbook is designed for people who can see color, but should also be accessible to color-blind readers to whom the colors will appear as different shades of gray. The full-color version is available as a PDF on the course Website. When the textbook passes beyond the v0.x stage and is ready for a first formal printing, it will be available as book printed in color. Later editions will be supplied with sound recordings of the text to help visually impaired students and for general application in review (e.g., listening to chapters while travelling – or as a perfect way of being put to sleep).

Etymologies

Throughout the text, you will occasionally encounter footnotes that explain the origins (etymology) of technical terms. You are not expected to memorize any of these! They’re added simply as a tool to encourage students to learn and remember Greek and Latin roots that are often used in technical terminology. With experience, you may be able to at least guess at the meaning of phrases like “stygian obscurity” and “Sisyphean futility.”

Question Authority

If you don’t understand something, ASK! In all the years that I have been teaching (since 1963, when I tutored seniors in my high school who were failing their matriculation examinations), I have *never* criticized, sneered at, embarrassed or humiliated a student for wanting to understand something! And there’s an excellent chance that someone else in class has exactly the same question but hasn’t asked it yet. Think of all the time you can save for yourself and others simply by being unembarrassed and frank.

If you doubt my assertion, please speak with students who have completed other courses with me; I am confident that they will confirm that I am not a ****ing *%*#%\$ who abuses students!

In class, I often ask the class for snap judgements and often precede them with the comment that I don’t care if you are right or wrong – I’m just trying to keep your brains active. If you’re right, great! If you’re not, you’re learning without pain.

Don’t *ever* hesitate to ask a question in class, after class, by visiting me in my office, by Skype or by phone. I work for *you* and get enormous pleasure from helping people *get it*. If a professor (me too) ever says something you don’t understand, be sure to clarify the issue at an appropriate time. Don’t give up, ever.

In addition, students will quickly discover that I respond positively to constructive suggestions for improving the textbook, the exercises, the structure of the teaching system, homework, exams and examples. I keep a record of corrections and suggestions for improvement in the CONTINUOUS PROCESS IMPROVEMENT discussion group in NUoodle and grant extra points for such contributions. Finding and fixing errors are not embarrassing: I wholeheartedly support continuous process improvement and regard

huffy resistance to corrections or positive suggestions for improvement as an indication of mental rigidity, outright stupidity, or neurotic insecurity.

Exceptionally good contributions may even get you mentioned in the acknowledgements, as you can see for yourself.



Acknowledgements

As indicated in the Dedication page, it is impossible fully to describe the degree of support poured out upon me by my wife, Dr Deborah Black during this years-long project. She has not only tolerated the hours of absence as I slaved over the text but has enthusiastically greeted the latest cry of, “Another chapter done!” – for summer after summer.

I am eternally grateful to Dr Hugh Tyson and Dr Daphne Trasler, formerly of McGill University for their teaching and encouragement to pursue statistics professionally. Dr John J. Gilbert of Dartmouth College was an important force in my scholarly evolution and gave me tremendous support in my drive to become a statistician.

Former Dean Dr Frank Vanecek, statistician and economist Dr Mehdi Mohaghegh, and econometrician Dr Najiba Benabess (now Director), all of the School of Business and Management at Norwich University have showered me with enthusiastic encouragement and support of this project from the very beginning.

The 13 students in the Fall 2010 semester of the experimental session of QM213 at Norwich University in the School of Business and Management who used the first version of this text contributed many practical suggestions for improvement – either explicitly or simply through the difficulties they experienced with different aspects of the subject matter. Student Dejan Dejan in particular had many helpful and articulate suggestions for improvement of the text and of the course and I am particularly grateful to him. Many other students in the sessions since then have also been helpful and cooperative in locating errors and suggesting corrections and other improvements.

Finally, I must mention with gratitude Pop (Percy Black z”l) and Mom (Virginia Black), distinguished professors and professional writers themselves, whose constant encouragement was a real Wonderbra experience (i.e., “uplifting,” as Pop used to say).

Naturally, all errors are my own fault and, in the tradition of Monty Python, I grovel in the reader’s general direction.³ Please send corrections and suggestions for improvement to me through the NUoodle classroom’ *Continuous Process Improvement* section if you are one of my students or by external email if you are reading, studying, or using the text at another institution or on your own.

Mich

M. E. Kabay
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October 2016

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³ Based on *Monty Python’s Holy Grail*, Scene 8. French Guard: “I fart in your general direction.”
< <http://arago4.tnw.utwente.nl/stonedead/movies/holy-grail/main.html> >