BECOMING A WELL-PREPARED PSYCHOMETRICIAN

WHAT YOU SHOULD KNOW QUANTITATIVELY

(BUT MAYBE WERE AFRAID TO ASK)

I separate the quantitative competencies expected for an appropriately trained applied psychometrician into six general categories:

(A) applied statistics (emphasizing the behavioral [psychological] sciences)

(B) psychometrics

(C) multivariate analysis

(D) mathematical statistics

(E) computation

(F) the contexts of testing

Separate two course sequences now exist at Illinois, for example, for (A) through (D); single course offerings for (E) and (F) will be proposed in the near future

Two articles are given as handouts (to show how important it is to develop strong training programs in measurement and psychometrics):

As Test-Taking Grows, Test-Makers Grow Rarer

By DAVID M. HERSZENHORN

Published: May 5, 2006 (New York Times)

APA Task Force for Increasing the Number of Quantitative Psychologists Makes Plans

By Leona S. Aiken, Task Force Chair

I've included handouts on two other topics:

A listing of fourteen journals (first and second tier) that you should be browsing and/or having available to you —

A listing of some two-hundred books on test theory, measurement, and assessment that could be on your book shelf (or keep your eyes open for these in the used book stores) —

(A) Applied Statistics

Research design, research methodologies, and basic analytical procedures/statistical analyses.

This includes a strong understanding of the General Linear Model and its usage (formulated in matrix terms);

the special cases of analysis-of-variance; analysis-of-covariance; and common multiple regression.

Also, skills are needed in dealing with repeated measures designs (split-plots, profile analyses, and longitudinal modeling), and the incorporation of categorical data analysis to the level of loglinear models, logistic regression, generalized linear models, and the various subanalyses these encompass.

PSYCHOLOGY 406 Statistical Methods I

Techniques in applied statistics used in psychological research, including simple linear regression, partial and multiple correlation, and nonparametric methods; thorough review of statistical estimation and significance tests; emphasizes applied statistics and statistical computing. Introduces experimental design; one-way ANOVA.

PSYCHOLOGY 407 Statistical Methods II

Continuation of PSYCHOLOGY 406. Experimental design, including Latin Squares, factorials, and nested designs; expected mean squares, analysis of covariance; emphasizes the general linear model; introduces multivariate methods, such as factor analysis, scaling, classification, and clustering. Discrete multivariate analysis and multiway contingency tables.

Hays, W. (1994). *Statistics* (5th ed.). Belmont, CA: Wadsworth.

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W. (2005). *Applied linear statistical models* (5th ed.). New York: McGraw-Hill/Irwin.

Maxwell, S. E. & Delaney, H. D. (2003). *Designing experiments and analyzing data: A model comparison perspective*. Mahwah, NJ: LEA.

Agresti, A. (1996). *An introduction to categorical data analysis*. New York: Wiley.

(B) Psychometrics

Principles of psychometrics with a thorough understanding of both classical test theory (CTT) and item-response theory (IRT).

Necessary knowledge includes a complete mastery of how test reliability and validity are approached with both CTT and IRT; test equating; differential item functioning; generalizability theory; adaptive testing; cognitive diagnosis; test fairness and bias.

(Presumed as a Prerequisite for Theories of Measurement I and II)

PSYCHOLOGY 490 Measurement and Test Development Lab

The measurement of human behavior in psychological studies; the construction and use of psychological tests; introduction to tests of intelligence, achievement, personality, and interest; and practice in test construction, administration, and validation. Lectures and laboratory.

EDUCATIONAL PSYCHOLOGY 585 Theories of Measurement, I

Classical test theory (true score, error of measurement, reliability and validity of test scores, composite measures); proposed alternatives to the classical model (generalizability theory, matrix sampling, latent trait theory, criterion-referenced measurement).

EDUCATIONAL PSYCHOLOGY 586 Theories of Measurement, II (Item Response Theory)

The theoretical foundations and applications of IRT. Includes latent trait estimation, item parameter calibration, modeling and detection of differential item functioning, linking and equating, computerized testing.

Crocker, L. & Algina, J. (1986). *Introduction to classical and modern test theory*. New York: Holt, Rinehart, & Winston.

McDonald, R. P. (1999). *Test theory: A unified treatment*. Mahwah, NJ: LEA.

Lord, F. M. (1980). *Applications of item response theory to practical testing problems*. Hillsdale, NJ: LEA.

Embretson, S. E. & Reise, S. P. (2000). *Item response theory for psychologists*. Mahwah, NJ: LEA.

Hambleton, R. K., Swaminathan, H., & Rogers, H. J. (1991). *Fundamentals of item response theory*. Newbury Park, CA: Sage.

(C) Multivariate Analysis

Strong competencies in Applied Multivariate Analysis, including a thorough understanding for the place of factor analysis/structural equation modeling in psychometric applications (as well as in the history of psychology), along with the matrix analysis skills needed to deal competently with the Singular Value Decomposition of a matrix.

Additional skills are necessary in cluster analysis; multidimensional scaling; biplot representations; canonical correlation analysis; correspondence analysis; principal component representations; discrimination and classification; path analysis.

PSYCHOLOGY 594 Multivariate Analysis in Psychology and Education

Examines the principal methods of descriptive and inferential statistics used in the analysis of multiple measurements, emphasizing linear transformations, multiple regression, principal components, multivariate analysis of variance, canonical correlation and variates, discriminant functions and variates, and conventional procedures of factor analysis; involves both theory and applications.

PSYCHOLOGY 588 Covariance Structure and Factor Models

Introduction to covariance structure models, linear structural equations, and factor analysis; identification and parameter estimation problems; assessing goodness-of-fit; use of computer packages such as LISREL and EQS; applications to a wide variety of social and behavioral science modeling problems.

Johnson, R. A. & Wichern, D. W. (2002). *Applied multivariate statistical analysis* (5th ed.). New York: Prentice-Hall.

Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.

(D) Mathematical Statistics

A basic understanding of mathematical statistics that is calculus-based.

This differs from the emphasis in an applied statistics sequence in the sense of developing a strong mathematical understanding of what is typically taken for granted in an applied context.

This background should begin to develop the problem-solving skills necessary to become a methodology producer rather than just a sophisticated user.

STATISTICS 400 Statistics and Probability I

Introduction to mathematical statistics that develops probability as needed; includes the calculus of probability, random variables, expectation, distribution functions, central limit theorem, point estimation, confidence intervals, and hypothesis testing. Offers a basic one-term introduction to statistics and also prepares students for STATISTICS 410.

STATISTICS 410 Statistics and Probability II

Continuation of STATISTICS 400. Includes moment-generating functions, transformations of random variables, normal sampling theory, sufficiency, best estimators, maximum likelihood estimators, confidence intervals, most powerful tests, unbiased tests, and chi-square tests.

Hogg, R. V. & Tanis, E. A. (2005). *Probability and statistical inference* (7th ed.). New York: Prentice-Hall.

Hogg, R. V., Craig, A., & McKean, J. W. (2004). *Introduction to mathematical statistics* (6th ed.). New York: Prentice-Hall.

(E) Computation

Computational skills and background, including competencies in using all the common commercial software packages (SAS, SPSS, SYSTAT), plus the standard psychometric software (BILOG, MULTILOG, PARSCALE, NOHARM, TESTFACT).

the usual spreadsheet and database applications (e.g., EXCEL and ACCESS), plus some strong experiences in higher level programming languages such as MATLAB and R.

In addition, ability should be present for dealing with graphics (though Adobe ILLUSTRATOR, for example), and to write one's material in the quantitatively-oriented document processing program of LaTeX (and TeX).

(F) Contexts of Testing

An understanding of all phases of testing — construction of tests; administration of tests; and interpretation and use of test results — in their social, cultural, and historical contexts.

This issue applies across the range of types of testing contexts, including personality assessment; personnel testing and selection; clinical (psychiatric) assessment; intellective measurement; the setting of standards; instructional and student performance evaluation; neuropsychological evaluations; legal and criminal psychological assessment; child competency evaluation, among many others.

Brennan, R. (Ed.). (2006). *Educational measurement* (4th ed.). Washington, DC: American Council on Education and NCME.

AERA, APA, & NCME (1999). *Standards for educational and psychological testing*. Washington, DC: AERA.