Core Terms in Undergraduate Statistics

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I analyzed 3 introductory statistics textbooks to generate a listing of key terms and concepts. After removing duplications, 374 unique terms formed the master list. A national sample of introductory statistics instructors (N = 190) evaluated portions of the master list, rating each item on a scale ranging from 1 (not at all important) *to 3* (extremely important)*. I list the Top 100 items and offer recommendations about the usefulness of the importance listing in facilitating statistics instruction.*

An undergraduate course in statistics continues to be an essential component in the curriculum for the psychology major. After reviewing curricula from hundreds of colleges and universities nationwide, Perlman and McCann (1998) concluded that the core of the undergraduate major comprises introductory psychology, statistics, and a capstone course. Instructors of statistics face a host of challenges (Conners, Mccown, & Roskos-Ewoldsen, 1998; Hastings, 1982). For instance, Conners et al. listed four unique challenges in teaching the statistics course: (a) motivating students, (b) overcoming math anxiety, (c) avoiding performance extremes, and (d) making learning last. Given the prevalence of the statistics course and the unique challenges of teaching it, any resource available to facilitate instructor performance in teaching statistics would be highly valuable.

This study shares similarities with previous studies (e.g., Giesbrecht, Sell, Scialfa, Sandals, & Ehlers, 1997). Those authors had 18 professors from four different disciplines rate the importance of topics in research methods and statistics. Giesbrecht et al. obtained topic listings from previous research, review of statistics and research methods texts, and course descriptions, and "found interdepartmental agreement on the relative importance of 97% of the statistics topics, with 74% of those topics deemed to be important" (p. 245). In this study, I focused on statistics instruction at the undergraduate level only and within psychology only, and I base my conclusions on the responses of a national sample of undergraduate statistics instructors.

My goal was to generate a master list of statistical terms relevant to an undergraduate statistics course and then to ask statistics instructors to rate the importance of those terms in that context. Other researchers have successfully used this approach with introductory psychology terms (Boneau, 1990; Griggs & Mitchell, 2002; Landrum, 1993; Quereshi, 1993; Quereshi & Sackett, 1977; Zechmeister & Zechmeister, 2000). For instance, Zechmeister and Zechmeister performed a content analysis of terms using the glossaries of 10 introductory psychology textbooks and generated a list of 2,505 unique terms. After dividing the list into smaller sections, Zechmeister and Zechmeister then sent the sections to a sample of introductory psychology instructors for importance ratings. These top terms are construed as the core terms in introductory psychology.

There are potential benefits in having a set of core terms for an undergraduate statistics course. New instructors of statistics would have a valuable reference in helping determine course content. All statistics instructors would have the ability to compare their decisions about course content (especially across multiple sections) to the importance ratings of a national sample of statistics instructors. Regarding textbook selection, other approaches have been helpful in choosing a statistics book, such as assessing readability and writing style (Harwell, Herrick, Curtis, Mundfrom, & Gold, 1996). A core terms listing for statistics might also assist instructors in the textbook selection process. Instructors face time constraints regarding the content and topics of the course versus the length of the semester. Importance ratings might help instructors (or even statistics textbook authors) determine those topics that are less important. Making this type of informed choice might lead an instructor to come back to a topic at the end of a semester, time permitting. Thus, there are multiple plausible advantages to having a list of core terms in statistics rated by importance.

Method

Participants

Psychology department chairs received a cover letter explaining the purpose of this study, a survey, and a self-addressed business-reply envelope. I asked the department chair to forward the survey to an undergraduate statistics instructor. I mailed 814 surveys to colleges and universities in the United States that offered an undergraduate degree in psychology—I obtained this contact information from the American Psychological Association Office of Research. A total of 190 instructors responded with usable data, yielding a response rate of 23.3%.

Materials and Procedure

Prior to surveying statistics instructors for importance ratings, I developed a master list of terms; I describe that process here and the materials used to survey statistics instructors.

Generation of the master list. I selected a convenience sample of statistics texts (i.e., those that were on my bookshelf): Gravetter and Wallnau (1999), Pagano (1998), and Spatz (1997). The important details for each text follow: Gravetter and Wallnau: 458 pages, 16 chapters, 210 key terms; Pagano: 548 pages, 19 chapters, 238 key terms; Spatz: 488 pages, 14 chapters, 167 key terms. Because not all three books contained glossaries, I could not use previous content analysis techniques (e.g., Zechmeister & Zechmeister, 2000). Instead, I performed a page-by-page content analysis of all three books and selected terms in bold face type or italics. In some instances I used the heading of a particular section. I previously used a similar technique in my examination of introductory psychology textbooks (Landrum, 1993). At times, I had to make decisions about similar terms. For example, "line of best fit" and "best-fitting line" mean essentially the same thing; I eliminated one from the final list of terms. This decision was subjective; if terms were highly similar but not identical, I erred on the side of caution and included both terms.

The three statistics texts yielded 615 terms; 374 unique terms emerged to constitute the list of statistics terms. After some consideration, I decided not to compare terms chapter by chapter, as previously done in the content analysis of introductory psychology textbooks (e.g., Landrum, 1993; Zechmeister & Zechmeister, 2000). For instance, one book had a separate chapter for measures of central tendency and variability, whereas another combined the two topics into one chapter. Of the 615 terms coded, 44 terms appeared in all three books.

Importance ratings by statistics instructors. I believed that 374 statistical terms was too many to ask any one person to evaluate, so I randomly divided the listing of terms into three separate, mutually exclusive forms. Thus, each instructor rated a list of 124 or 125 terms, presented alphabetically. On average, 63.3 instructors (SD = 13.0) rated each list of terms. Participants rated each concept using a 4-point importance scale from 0 (*not at all important*), 1 (*slightly important*), 2 (*moderately important*), to 3 (*extremely important*). I instructed participants to leave an item blank if it was unclear, and I calculated a mean rating for each term. The term *normal curve* was the only term to receive a unanimous rating of 3.0 (for the means and standard deviations of the top 100 terms, see Table 1).

Table 1. Means and Standard Deviations for the Top 100 Terms

Item	*M*	*SD*
Normal curve	3.00	0.00
Statistically significant	2.98	0.13
Bell-shaped curve	2.96	0.18
Significance level	2.96	0.18
Hypothesis testing	2.96	0.19
Normal distribution	2.96	0.19
Standard deviation	2.96	0.19
Sample	2.94	0.22
Alpha level	2.94	0.23
Mean	2.93	0.25
Null hypothesis	2.93	0.37
Central tendency	2.92	0.26
Inferential statistics	2.92	0.31
Variability	2.92	0.31
Arithmetic mean	2.91	0.28
Correlation	2.90	0.29
Pearson correlation	2.90	0.29
Dependent variable	2.89	0.34
Two-tailed probability	2.89	0.44
Positive correlation	2.88	0.37
Data	2.88	0.38
Hypothesis	2.88	0.45
t test	2.87	0.51
Descriptive statistics	2.86	0.34
Variance	2.86	0.34
Negative correlation	2.86	0.43
Not significant	2.85	0.44
Variable	2.84	0.42
Population	2.84	0.52
Statistic	2.84	0.52
Level of significance	2.83	0.37
Critical values	2.83	0.46
Type I error	2.82	0.46
Degrees of freedom	2.81	0.43
Median	2.81	0.44
Significant effect	2.81	0.53
Rejection region	2.81	0.57
t test for independent-samples design	2.81	0.57
One-way ANOVA	2.80	0.44
Statistical inference	2.79	0.46
Two-tailed test of significance	2.79	0.51
t test for independent groups	2.79	0.58
t statistic	2.79	0.63
Standard error of the mean	2.77	0.55
Critical region	2.76	0.50
Standard error	2.75	0.58
ANOVA	2.75	0.63
Inferential process	2.74	0.57
Alternative hypothesis	2.74	0.60
F ratio	2.73	0.48
Deviation	2.73	0.58
Distribution of sample means	2.73	0.59
Student's *t* test	2.73	0.66
Linear relationship	2.72	0.55
Independent-samples design	2.72	0.64
z score transformation	2.72	0.67
Random	2.71	0.61
Random assignment	2.71	0.62
Sampling error	2.70	0.51
Correlational method	2.70	0.60
z score	2.70	0.72
Null-hypothesis population	2.68	0.65
Frequency	2.67	0.54
Independent groups design	2.67	0.58
Frequency distribution	2.67	0.70
Independent variable	2.66	0.63
Type II error	2.64	0.64
One-tailed probability	2.62	0.67
Random selection	2.62	0.72
Nondirectional hypothesis	2.61	0.64
Sampling distribution	2.61	0.71
Estimated population standard deviation	2.60	0.63
Overall mean	2.60	0.67
Correct decision	2.60	0.77
Sampling distribution of the mean	2.59	0.72
Sampling distributions of a statistic	2.59	0.72
Regression	2.59	0.81
Causation	2.58	0.56
Scatterplot	2.58	0.61
Sum of squares	2.57	0.63
Positive relationship	2.55	0.67
Sampling distribution of *t*	2.55	0.73
Sum of squared deviations	2.55	0.77
Test statistic	2.55	0.82
Chi-square distribution	2.54	0.65
Between-groups sum of squares	2.54	0.75
Simple random sample	2.54	0.75
Population variance	2.53	0.72
Random sampling	2.52	0.78
t distribution	2.51	0.69
Chi-square statistic	2.51	0.78
One-tailed test of significance	2.51	0.78
Probability	2.50	0.70
Standard score	2.50	0.75
F distribution	2.50	0.83
Distribution of scores	2.49	0.64
ANOVA summary table	2.49	0.74
Treatment	2.49	0.75
Levels/treatments	2.49	0.78
Subjects/participants	2.49	0.81

Discussion

The results of this study, as presented in Table 1, provide an interesting look at what statistic instructors consider important. This Top 100 list may be construed as a first approximation of the core of introductory statistics in psychology. These results may also help instructors decide what the important terms to cover in class are and what terms are secondary. The approach of this study is unique because only undergraduate statistics instructors rated the importance of terms. Departments that offer multiple sections of statistics taught by different instructors using different textbooks might find these results useful in an effort to coordinate consistent coverage of the various content areas of statistics. The results of this study are more specific to psychology instruction than those from a previous study (Giesbrecht et al., 1997).

For some semesters, instructors may not cover certain chapters of information they consider less important; other semesters they may cover those chapters. What topics sometimes get deleted due to time constraints? The listing presented in Table 1 should help instructors and authors to answer these questions by understanding the core terms in the context of relative importance.

This study has limitations with regard to the methodological approach used, including the convenience sample of textbooks. In addition, in the instances where terms were highly similar but not identical, I included all terms. More work in this area is warranted to continue to verify the core terms. The listing provided here can be valuable for instructors in designing and making choices about the coverage of topics in an introductory course in statistics.

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Notes

1. The comprehensive list of means and standard deviations for all 374 terms is available from the author.
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Promoting Conceptual Understanding of Statistics: Definitional Versus Computational Formulas

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Computer applications have replaced hand calculations as the relevant procedural skill for most of the statistical techniques in introductory statistics courses. Therefore, definitional formulas should replace computational formulas because only the former contribute to conceptual understanding. A review of 12 introductory statistics textbooks indicated that they emphasized computational formulas, particularly for complex techniques and exercises. We argue that the presentation and use of computational formulas is counterproductive to the learning goals of statistics courses and provide recommendations for instructors to facilitate the use of definitional formulas.

In the precomputer era, when students performed calculations by hand, computational formulas provided heuristics for difficult computations but sacrificed understanding of the underlying statistical concepts. Currently, however, 69% of psychology departments use computers in introductory statistics courses, and 90% use them for data analysis at some point in their curriculum (Bartz & Sabolik, 2001). Computers perform most statistical analyses. Thus we question the continued need for computational formulas and advocate instead for definitional formulas computed using hand calculators.

Although hand calculations are less tedious when using computational formulas, definitional formulas provide students with some perspective as to what the statistic is, when to use it, and how to interpret it. Consider, for example, the definitional,

$$s^2 = \frac{\sum_i (X_i - M)^2}{N},$$

and computational,