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ABSTRACT

Recent articles in behavioral sciences statistics literature address the need for modernizing graduate statistics programs and courses. This paper describes the development of one such course and evaluates student background for a class designed to provide a more consumer-oriented type of statistics instruction by focusing on the needs of students who are not statistics majors. The course for nonmajors focuses on key concepts for the effective understanding of research findings and uses only one statistical package, with the goal of increased understanding. As part of the development of the course, the importance of differences in student backgrounds, specifically quantitative skills was studied. Results with 28 students from 12 majors show that skills used are not differentiated by the entering levels of preparedness in quantitative areas. These results suggest that expansion of statistics courses to include applied statistical skills can be successful for students from different majors. (Contains 1 table and 21 references.) (SLD)

Running head: STATISTICS

Statistics: Can We Get Beyond Terminal?

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Abstract

Recent articles in behavioral sciences statistics literature address the need for modernizing graduate statistics programs. Academia, industry, and government need graduates who can effectively communicate results and conclusions of research projects. Recent literature discusses the development of more consumer-oriented applied statistics programs for majors while overlooking the largest group of consumers of these courses, the nonmajors. This paper presents the development of such a course and the results of a pilot study which included the evaluation of applied skills. Results showed that the skills used were not differentiated by entering levels of quantitative preparedness.

Key Words: teaching non-majors

1. DIRECTIONS IN TEACHING STATISTICS IN THE SOCIAL SCIENCES AT THE GRADUATE LEVEL

Recent articles in statistics literature address the need for modernizing graduate statistics programs (Garfield 1995; Lehoczky 1995; Tucker 1995). They seem to share a consensus on the importance of teaching students the relevance and long-term uses of the statistical concepts being taught for a modern society. A terminal statistics course experience must no longer be considered acceptable in a world requiring ongoing understanding.

The need for statistics expressed in the literature does not appear to be supported by student enthusiam. Students often see statistics as the worst course taken at the college level (Hogg 1991), with many exhibiting negative attitudes and lack of excitement for the topic (Borresen 1990; Wise 1985). Even at the doctoral level, "most [students] will tend to see their work in statistics as terminal" (Blalock 1987, p. 164). Few students in statistics courses have "expectations of building upon them in a sustained manner" (Blalock 1987, p. 164). Yet, statistics is clearly an important tool in scientific discovery that significantly impacts modern society.

The task facing instructors, then, is to create an atmosphere for learning in which students realize real world value and long-term uses for knowledge, understanding and skills in statistics. Students "can't value what they don't understand" (Snee 1993, p. 150). Some authors suggest that to create this learning atmosphere significant changes must be made in statistical education, e.g., courses should expand to incorporate applied statistical skills to an ever growing knowledge base of statistical concepts (Garfield 1995; Hogg 1991; Snee 1993).

Compared to 25 years ago, today's graduate students, even non-majors, need to master an enormously large body of material in statistics in addition to computer skills before they can be considered literate (Garfield 1995; Lehoczky 1995). Statistical literacy can be defined as the ability to read and understand statistical concepts, conduct statistically-based research, and effectively employ a statistical consultant (Brogan & Kutner 1986).

Academia, industry, and government need graduates who can effectively read, write, and orally express the methods and results of statistical analyses and conclusions of research projects (Bickel 1995; Kettenring 1995; Ross 1995). Statisticians are being called upon more than ever before to aid in solving real-life problems that inflict society (Bailar 1995). It seems reasonable that all professionals, not just statisticians, need to have practical understanding and interpretive skills of statistical concepts.

2. NON-MAJORS ARE OUR MOST FREQUENT CLIENTS

There has been much written on the needs for updating programs for graduate students majoring in statistics (Lehoczky 1995; Snee 1993). Yet, the largest group of students taking graduate statistics courses are non-majors from many different disciplines with varied statistical backgrounds (Cerrito 1994). There appears to be very little written on the need for including applied statistical skills to the course curriculum for this substantial group of students. We agree with the faculty respondents in the Curtis and Harwell survey (1996) that, in general, this group of students is under-prepared to be critical consumers of empirical research. This is a disservice to our students whether they are business, communications, counseling, or education majors.

It is our contention that the current deficit in teaching non-statistical-majors deserves greater exploration. Statistical application skills including article critiquing and computer interpretation seem to be a necessary starting place in this process. This paper presents the development of such an application skills focused course and the results of a pilot study which included statistical application skills in a classroom curriculum.

Perhaps, like us, you teach graduate students who have diverse quantitative backgrounds from very substantial or recent statistics courses, to those whose only quantitative course of any type was taken many years ago (if at all). The task of teaching these students is further complicated by the sheer volume of knowledge which has to be transferred in a limited time frame. Over and above that is the negative attitude exhibited by many students toward course material. An additional problem arises if the instructor teaches students who are not uniform in their areas of study. Most students come from within our college, but even that accounts for a minimum of six different areas of study. The combination of these factors creates the challenge for the educator to not only identify and meet the common statistical needs of a diverse student body, but also to develop ways to appropriately evaluate progress.

3. GENERATION OF A DIFFERENT DIRECTION

Traditional teaching of statistics focuses on mathematical manipulation, probability estimation, and computer programming, but there is a persistent call for a move to greater emphasis on statistics as a way to communicate and as a problem solving tool. Numerous discussions and papers at proceedings of the Committee on Applied and Theoretical Statistics of the National Research Council in 1991 and 1992, and at the 1993 symposium on Modern Interdisciplinary University Statistics Education have given great attention to this even if the literature has not (Tucker 1995).

A common use of statistics to communicate is in the form of the quantitative results sections of our own research. In order for information to be transferred, the communication must be understood. Understanding what is being communicated is one area in which we have failed to provide adequate training. A recent survey of 21 faculty showed that nearly all thought that less than half of the non-quantitative majors were competent to critically read and interpret research articles for several statistical techniques (Curtis & Harwell 1996). The necessity of being able to effectively consume the quantitative sections of empirical literature is beginning to be suggested by statistics instructors (Blalock 1987; Cerrito 1994), but the inclusion of methodologies to accomplish that goal is not yet routine.

4. WHAT EVERYONE NEEDS TO KNOW

We always ask the students at the beginning of the course to describe their previous statistical experience and for input on what they hope to receive from their experiences in the course. This information is invaluable in identifying strengths and defining needs. It is helpful to partition need into long-term and short-term categories. This breakdown is crucial since statistics can be typically thought of as an area in you lose it, if you don't use it. Highly repeated among the student responses is the need for the ability to read the results sections in quantitative research articles. This need appears as a common thread whether one is studying to become a principal, a counselor, a college president, or curriculum consultant. The most frequent long-term usage of these skills for students is to understand and critically evaluate the quantitative results of empirical research.

Our approach explores key concepts for effective article understanding including the ability to: (a) discern a mismatch between the scale of measurement of the data collected and the statistical method used to analyze the data, (b) recognize the reasonableness (or lack thereof) of the operational definition of the construct being researched, (c) identify potential issues of internal and external validity, (d) make a distinction between statistical significance and practical significance (in terms of effect size), and, (e) recognize a mismatch between what is reported in the results section and what is alleged in the conclusions section. Skills in calculating statistical tests are not necessary to address these few concepts.

The students in our course have the opportunity to read and discuss empirical research articles using the statistical technique about which they were learning. Discussion often takes place within small study groups outside of class. Open critiques from the students in class are generally lively. The most puzzling issue, and the most difficult thing for students to accept, appears to be how there could be flaws in an article that was peer reviewed and published.

Students were evaluated on their written responses to a series of questions relating to two different articles that they had the opportunity to read and discuss with classmates prior to in-class queries. Partial credit was given whenever possible as there were sometimes quite divergent (yet acceptable) responses to a query based on the student's own background and experience. On reflection, we often added as much to our own experiential knowledge base if not more than the students!

The ability to use the computer is another need desired by our students that is just as strongly recognized by instructors in the field. "Computer use was the second most frequent topic of empirical writing on statistics instruction" (Becker 1996, p. 79), and "for nonempirical documents, one of the two most common topic categories" (Becker 1996, p. 80).

Students learning educational statistics as their major will need to be exposed to a variety of computer languages, but students taking the course as a research requirement do not need to approach this level in either quantity or quality. Our service course for non-majors uses only one statistical package with the goal of increased understanding. We do not advocate the indiscriminant use of computer analyses made available with more user friendly programs without the user having an understanding of the appropriateness of the use. This is another area of frequent student misunderstanding of the limitations of the computer; no matter how sophisticated the program, it cannot think for you; it cannot develop an important and well thought out research hypothesis; it cannot tell you whether your results are meaningful.

Not all students will retain the skills to write computer programs far into the future. What we do suggest is that they should: (a) know what they want from a statistical package, and (b) be able to interpret the results. This base will assist them in the short-term to complete the requirements for their degree and in the long-term to conduct their own research, answer questions, solve problems, and communicate.

The accomplishment of these tasks require the student to know at a minimum: (a) when it is appropriate to apply a particular technique, (b) when violations of assumptions render a chosen technique inappropriate, and, (c) when statistical significance does not support practical significance. Therefore, students were also evaluated on the ability to interpret a given computer output focusing on these three areas.

Bessant (1992) has said about sociology students that the basic and traditional statistics instruction methodologies usually forego teaching the "relationship between theory, statistical analysis, and empirical reality" (p. 143). An introductory service course should therefore emphasize applied statistics. We would prioritize our students' need for empirical reality; unfortunately, most students have only had the exposure to theory and statistical analysis.

5. TEACHING METHODS

Empirical research in the area of teaching quantitative methods (mathematics, statistics, computer languages) has consistently shown a statistically significant performance difference between those who have a quantitative background and those who do not (Fishbein, Langmeyer, Brooks, and Rogers 1990; Gratz, Volpe, and Kind 1993; Shannon 1992). These studies define performance in traditional, number (or keyboard) crunching ways, which we find less appropriate for our students' needs. We were curious to know whether differences in quantitative background would show a statistically significant performance difference in the areas we have decided to emphasize, namely the ability to understand statistics in the empirical literature, and the ability to critically interpret computer results. As students provided a written report of their self-described, most important, prerequisite strength at the beginning of the quarter, we were able to take a tentative look at this question.

Data from students' consisted of three measures taken during a doctoral level introduction to educational statistics course taught by the primary researcher and assisted by the secondary researcher. The measures, quantified as number of points correct, are described as follows: (1 & 2) two short answer type assignments given in class on the critical evaluation of articles and (3) an objective type final examination on computer output interpretation. Using the students' self-reported primary categorization regarding general preparedness for the course we identified three areas (statistical experience versus computer experience versus no experience). The statistical method used was multivariate analysis of variance.

6. RESULT: THEY LEARNED ABOUT THE SAME

The characteristics of the students testifies to the diversity of their backgrounds and future needs regarding applied statistics understanding. Sixty-eight percent of the students were housed in the College of Education. These 28 students comprised 12 different majors. Thirty-two percent of the students were housed in the College of Communication. Three different majors were represented by these 13 students. Gender split among the group slightly favored the females (23 versus 18 males). There were more international students (22) than domestic (19). The within diversity of the international students is clear as they hailed from countries associated with three different continents. There were twice as many international males (12) as domestic males (6), while the breakdown among females was more equitable (international-10, domestic-13).

The three groups (statistical experience, computer experience, and no experience) did not differ statistically on the three outcome measures at the multivariate level [Wilk's $F(6,72)=1.27$]. The effect size of .10 can be considered small (Cohen 1988). The means, standard deviations, sample sizes, and univariate effect sizes are shown in Table 1.

7. NEXT DIRECTION

Our current challenge as instructors is to provide students with the skills necessary to allow them to competently use statistics in their chosen fields. It is important that the deficits in teaching identified in the literature, especially with the non-majors, be addressed. We need to face disconcerting results, such as faculty believing that less than half of the non-quantitative majors were competent to critically read and interpret research articles (Curtis and Harwell 1996).

We would like to call upon statistics instructors to consider their perspective of major students' competencies versus non-majors. The influx of non-majors into our courses necessitated the opening of two course sections, a first, with attention being paid to the needs of this burgeoning group from different disciplines requesting an application oriented statistics course. We believe that they deserve more than being treated as though they are "along for the ride" with the focus going to majors in the class.

It would appear from our experience and the results of the pilot study that the skills necessary for critical understanding of empirical research and computer interpretation of statistical results were not dependent upon the quantitative background of the students. It would seem that the expansion of statistics courses to include applied statistical skills can be successful, regardless of diverse student background, as well as provide our students with relevant uses for knowledge, understanding, and skills in statistics.

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Table 1. Performance Data by Preparedness Category

		Mean	Standard Deviation	Effect Size[a]
Variable .. ARTICLE #1				
Prerequisite Experience	(n)			
computer	(11)	72.27	20.17	
statistics	(18)	69.17	20.09	
none	(12)	57.92	13.56	.096
Variable .. ARTICLE #2				
Prerequisite Experience	(n)			
computer	(11)	82.18	12.08	
statistics	(18)	84.33	10.49	
none	(12)	85.83	10.74	.016
Variable .. COMPUTER INTERPRETATION				
Prerequisite Experience	(n)			
computer	(11)	18.73	1.85	
statistics	(18)	19.22	2.58	
none	(12)	17.00	2.98	.130

[a]Eta squared.

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