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ABSTRACT

The purpose of this study was to examine doctoral students' preparation in statistics in the field of education. A national survey was conducted focusing on 27 quantitative methods (QM) programs. One QM professor from each program was identified and asked to describe and evaluate the training of QM and non-QM doctoral students at his or her institution. The vast majority of professors indicated that most or all of the students in their QM programs received training in the "old standard" procedures, analysis of variance, multiple regression , and traditional multivariate procedures, while fewer than half of the professors indicated that most or all of their QM students received training in more recent procedures such as bootstrapping and multilevel models. Professors were also asked to rate the skills of the QM students' training in areas such as mathematical statistics and computer skills on a scale from "Weak" to "Strong." Most professors gave high marks to their QM students' skills with statistical packages, but gave much more mixed ratings of their QM students' training in mathematical statistics. Nearly half of the professors thought that most of their QM students could have benefited from one to two additional statistics courses. Results are discussed in terms of training of future doctoral students. (Contains 10 tables.) (Author/SLD)

Training Graduate Students in Educational Statistics: A National Survey

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Abstract

Although numerous research studies have focused on issues related to the teaching of statistics, few studies have focused on the training of people who may become statistics teachers. The purpose of this study was to examine doctoral students' preparation in statistics in the field of education. A national survey was conducted of twenty-seven quantitative methods (QM) programs. One QM professor from each program was identified and asked to describe and evaluate the training of QM and non-QM doctoral students at his or her institution. The vast majority of professors indicated that most or all of the students in their QM programs received training in the "old standard" procedures--ANOVA, multiple regression, and traditional multivariate procedures, whereas less than half of the professors indicated that most or all of their QM students received training in more recent procedures such as bootstrapping and multilevel models. Professors were also asked to rate the skills of their QM students' training in areas such as mathematical statistics and computer skills on a scale from "Weak" to "Strong". Most professors gave high ratings to their QM students' skills with statistical packages, but gave much more mixed ratings of their QM students' training in mathematical statistics. Nearly half of the professors thought that most of their QM students could have benefited from 1 to 2 additional statistics courses. Results are discussed in terms of training future doctoral students.

Training Graduate Students in Educational Statistics: A National Survey

There are several indications that the level of methodological and statistical sophistication required of graduates of doctoral programs in education has been increasing over the years. In terms of educational statistics, we have witnessed the relatively recent introduction of a wide variety of advanced statistical methods into the field of education, including meta-analysis, bootstrapping, multilevel modeling, and structural equation modeling. We have also seen the field of qualitative methods develop from a small educational research camp to a major educational research paradigm. It is no longer unusual to find an issue of a research journal where one article utilizes complex statistical procedures and a second article utilizes a rigorous qualitative analysis. For example, journals as diverse as *Exceptional Children, TESOL Quarterly* (Teaching English to Speakers of Other Languages), and *Journal for Research in Mathematics Education* consistently publish both quantitative and qualitative research. A well-rounded graduate of a doctoral program in education thus needs a remarkable breadth and depth of knowledge of research methods and statistics, whether it be to critically evaluate research articles, to conduct research, to write and evaluate grant proposals, to serve as editorial board members for scholarly journals, or to supervising master's theses and doctoral dissertations. As faculty members who are responsible for training doctoral students in research methods and statistics, a key question then becomes how well are we actually preparing these students for their future roles as researchers and research consumers.

This paper focuses on one aspect of doctoral student preparation, namely preparation in educational statistics.[1] In particular, the purpose of this current research is to conduct a survey of doctoral students' training in statistics. This survey addressed the statistical training of two groups of doctoral students, namely those students who specialize in quantitative research methods (loosely defined to include doctoral students interested in research design, educational measurement, and educational statistics), and those students who specialize in fields other than quantitative research methods. Examining the training of this first group, namely doctoral students specializing in quantitative methods (QM), was considered important because these students may become tomorrow's leaders in quantitative methods, taking on responsibilities such as training future doctoral students in statistics, measurement, and research methods; publishing original research in statistics, measurement, and research methods; providing

[1]Ideally, we would have also considered doctoral students' training in measurement and research methods (including qualitative methods). We chose to focus on one aspect of training, namely educational statistics, to make this research project more manageable in scope.

methodological advice on master's thesis and doctoral dissertation committees; serving as methodological consultants to educational journals; and so forth. Examining the training of this second group, namely non-QM doctoral students, was also considered important, because these doctoral students may eventually become leaders in substantative areas of educational research.

Background

There is limited literature on doctoral students' training in educational statistics. A survey of statistics course content for doctoral students has never been conducted in the field of education, although studies of statistical preparation have been conducted in psychology (see Akin, West, Sechrest, and Reno, 1990) and medicine (see Dawson-Saunders, Azen, Greenberg, and Reed, 1987). The lack of systematic research on what doctoral students are learning in their statistics classes in the United States seems particularly unfortunate, because this information could help facilitate discussions of whether this training should be restructured and, if so, how it should be restructured. This is not to say that discussions of what <u>should</u> be taught do not take place. For example, Tukey (1980), among others, has argued that students need much more experience with exploratory data analysis in their statistics training. As a second example, Noether (1980) has argued for the importance of teaching nonparametrics in introductory statistics classes, arguing that it can provide a strong conceptual framework for students. Brogan (1986) similarly suggested that nonparametrics should be taught, especially in social science and nursing disciplines. Brogan further recommended that in a required two-course statistics sequence, graduate students should learn about general linear models, including multiple linear regression, ANOVA, and possibly categorical data analysis, and should also be trained to use computer statistical packages.

Content analyses of the types of statistics and research designs currently being used in published research can serve as a foundation for discussions of what we should be teaching. A number of such content analyses have been performed over the years. Elmore and Woehlke (1988), for example, conducted a content analysis of statistical methods used in the American Educational Research Journal (AERJ), Educational Researcher, and Review of Educational Research for all articles published between the years of 1978 to 1987. For AERJ, they found that the predominant statistical method used in these articles was ANOVA/ANCOVA, which was used in 137 out of 396 articles that they coded. The next most frequent procedure was multiple correlation/regression, which was used in 24% of the articles; followed by multivariate procedures (13%), bivariate correlation (12%), t-tests (11%) nonparametrics (12%), and structural equation modeling (10%). Assuming that the statistical analyses found AERJ are typical of those that doctoral students in education encounter, then it would seem reasonable to ask about the extent to which we are training doctoral students to conduct and interpret research which utilizes these procedures.

Aiken, West, Sechrest, and Reno (1990) examined the adequacy of doctoral student preparation in statistics in their own field, namely psychology. Because our research is similar to theirs, we will describe it in detail. In particular, Aiken, West, Sechrest, and Reno surveyed all 222 psychology departments or schools identified by the American Psychological Association as granting doctoral degrees. From these 222 units, 186 responded, for a response rate of 84%. The goals of their research were (a) to describe the current content of the statistics, measurement, and research design courses; (b) to look at differences in requirements between sub-disciplines in psychology; and (c) to gather data on professors' perceptions of students' abilities to apply statistical and measurement techniques in their own research. In addition, these researchers distinguished between "elite" and "other" institutions, and presented their data comparing the two types of institutions.

In terms of demographics, Aiken, West, Sechrest, and Reno (1990) found that 89% of the departments offered introductory graduate statistics sequence, and of the departments offering this sequence, 77% were one year in length. A minority of institutions--17%--offered doctorates in a quantitative area of specialization, and one-third of these 17% did not have any first-year students. In terms of curriculum offerings (including optional and required courses), the researchers found that in statistics courses, the majority of programs offered at least a partial course (defined as at least a half a semester or full quarter) in ANOVA (88% of the programs), multiple regression, (58%) and MANOVA (53%). More recent statistical topics such as structural equation models and time series models were covered in a minority of programs (18% and 6%, respectively). In terms of the content of the required introductory statistics course sequence, the authors distinguished between "old standards of statistics" and "more advanced statistical considerations", and collected information on the percent of institutions offering in-depth coverage of specific procedures. ("In-depth" was defined as coverage to the point that students could perform the analysis in question themselves). In-depth coverage of the "old standards" was provided in the majority of institutions: multifactor ANOVA, multiple comparison procedures, repeated measures via traditional factorial ANOVA, and multiple regression were covered in-depth in the required course sequence in 73%, 69%, 73% and 63% of the institutions, respectively. Topics considered more advanced tended to be covered in-depth in required courses much less often. For example, 39% of the institutions provided in-depth coverage of ANCOVA in their required course sequence, 38% provided in-depth coverage of ANOVA as a special case of regression; 20% provided in-depth coverage of exploratory data analysis, 21% provided in-depth coverage of multivariate procedures, and 18% provided in-depth coverage of statistical power analysis. The researchers interpreted these findings by stating that

> the statistical and methodological curriculum has advanced little in 20 years; measurement has experienced a substantial decline. Typical first-year courses serve well only those students who undertake traditional laboratory research...New PhDs are judged to be competent to handle traditional techniques, but not newer and often more useful procedures, in their own research. (p. 721)".

Our purpose was similar to those of Aiken, West, Sechrest, and Reno (1990), namely to conduct a survey of doctoral students' training in statistics. First, we were interested in learning about the kinds of statistical methods and procedures in which QM students and non-QM students in education are trained. Second, we were interested in learning about QM professors' perceptions of QM and non-QM doctoral students' competence with various statistical techniques.

Methods

Sampling Procedure and Instrumentation

The universities we surveyed are prominent educational research institutions, namely those institutions identified in a University of Illinois study as the top thirty-one Colleges of Education ranked in terms of academic productivity and prestige (West & Rhee, 1994). A list of these institutions is provided in Table 1. Our goal was to identify one QM professor from each institution as a contact person who would complete the questionnaire. If a program had a QM program, we selected a faculty member affiliated with this program. In order to identify these contacts, several strategies were used. First, we simply identified people that we knew personally at specific universities, with the belief that these people would be most likely to complete the questionnaires. Second, we used the membership roster of the AERA Educational Statisticians Special Interest Group. Because the results of this study would be presented at the AERA conference, we believed that using this membership roster would increase our chance of having the questionnaires completed and returned. Third, we used a book entitled "Graduate Study in Educational and Psychological Measurement, Quantitative Psychology, and Related Fields", published by the Pennsylvania State University, which lists quantitatively-oriented programs in the United States, and provides names of appropriate contact persons. Finally, in a few instances, we used personal contacts to identify a non-quantitative faculty member at a particular university who then gave us the name of a person who taught statistics at that university. There were only two instances where we could not identify a contact at a given university, leaving an effective population of 29 universities.

Our intention was to collect data from all 29 universities, regardless of whether or not they had quantitative methods (QM) programs. Moreover, we decided to be flexible in terms our definition of what a QM program is--thus, for example, some programs might place a heavy emphasis on measurement, whereas others might place a heavy emphasis on educational statistics. To figure out which universities had a QM program, we also used our personal knowledge of various universities. In cases where we were not sure if a university had a QM program, we attempted to contact someone at that university. Out of the 29 universities, all but 2 had QM programs. (These two Schools/Colleges without QM programs still offered doctoral training in statistics.)

Two versions of the questionnaire were developed. The first version was a four-page questionnaire, and was designed for the 27 universities that had a QM program. For these 27 universities, the QM faculty were asked to evaluate both the QM and non-QM doctoral students. The second version of the questionnaire was a one-page shortened version of the full questionnaire, and was designed for the 2 universities which did not have a QM program. For these 2 universities, the QM faculty were asked to evaluate the non-QM doctoral students only. A copy of the full-length questionnaire is provided in Appendix 1.

In November of 1995, all participants received a copy of the questionnaire (which will be described later) to complete. A second mailing was conducted approximately one month later, in December of 1995. In January 1996, this second mailing was then followed by e-mail and/or phone calls asking that participants return their questionnaires. All questionnaires received within 3 months of the initial mailing were then analyzed. In terms of the number of responses, 20 of the 27 universities with QM programs responded, and 1 of the 2 universities without QM programs responded. In total, 21 out of 29 universities responded, for a response rate of 72%. We believe that this response rate is large enough to generate credible results, although it is possible that there is some unknown but systematic difference between QM faculty members who responded to the survey and those who did not respond.

Designing the questionnaire: QM students. For the portion of the questionnaire addressing the training of the QM doctoral students, the process of questionnaire development was relatively straight-forward. For this group, we collected the following data:

(a) demographic information, including information on the number of full-time faculty in the QM program, the number of lecturers in the QM program, the number of students in the QM program, and the where on the campus students took their required statistics courses (e.g. in the School/College of Education, Statistics department, etc.),

(b) information on the extent to which QM doctoral students have been trained in specific statistical topics or methods,

(c) information on professors' opinions about the adequacy of QM doctoral students' computer skills and mathematical training, and

(d) information on professors' opinions on whether the QM doctoral students could have benefited from more statistics coursework.

Designing the questionnaire: Non-QM students. For the portion of the questionnaire addressing the training of the non-QM students, the development of the questionnaire was more challenging because the questionnaire items needed to be sufficiently flexible to accommodate the variety of ways in which Schools and Colleges of Education are organized. Specifically, a College of Education might consist of a series of schools, divisions, departments, or other organizational units, each with separate programs. Each organizational unit could conceivably have its own statistics requirement, with its own statistics course sequence. A non-QM students with one area of specialization at a particular institution could therefore take one required statistics course taught in one particular organizational unit, whereas another student with a different area of specialization could take a different required statistics course taught in a different organizational unit.

Considering all of these potential complexities, it became apparent to us that complete survey of what non-QM students learn in their statistics courses would require that <u>all</u> of the statistics instructors be surveyed in each organizational unit at each institution. We thought that such a survey would be too unwieldy, and decided to shift the focus for the non-QM students away from a survey of <u>course</u> <u>content</u> and <u>course requirements</u> and towards a survey of quantitative professors' perceptions of non-QM doctoral students' preparation in educational statistics. We asked one professor at each institution to evaluate doctoral students' training in educational statistics at his or her institution and to frame this evaluation in terms of doctoral students with whom he or she had direct contact with over the past few years--through committees, research assistantships, classes, and so forth. In this way, we hoped to circumvent potential problems of (a) having professors speculate about what was taught in statistics classes they might not have thorough knowledge about, and (b) having professors speculate about the statistical competence of doctoral students whom they might not know.

For the non-QM students, we collected the following data:

(a) information on statistics requirements,

(b) information on whether statistics requirements have changed over the past 5 years,

(c) information on professors' perceptions of doctoral students' ability to critically read and interpret research articles utilizing specific statistical procedures, and

(d) information on professors' opinions on whether the non-QM doctoral students could have benefited from more statistics coursework.

Limitations of the Current Research

Before presenting the results, we believe that it is important to point out three main limitations of the current research. First, the questionnaire was not extensively field tested, and no reliability or validity information was obtained for the questionnaire items. In fact, several of the items had to be excluded from the analysis because of apparent problems. Second, only one QM faculty member was surveyed from each institution, thus limiting the generalizability of the results. Third, because of time and resource constraints, we did not collect survey data on doctoral students' preparation in the areas of educational research methods or measurement, thus limiting the picture we can paint about doctoral student training. But, on the positive side, we believe that the survey has several advantages, among them the facts that (a) it is not particularly time consuming research method, and (b) it is not particularly intrusive.

Results

I. Statistics Preparation of QM Students in Education

Demographics. First consider the data for the QM programs and students. Demographic information is presented in Table 2. In terms of faculty size, the median size the full-time tenure and tenure-track faculty in these QM programs is 5, with 4 full-time faculty regularly teaching statistics during the academic year. In terms of student enrollment in QM programs, the distribution was positively skewed, but typically, approximately 4.5 students were admitted annually during the previous 5 years. In terms of the location of the required statistics courses, all of the institutions required students to take at least one statistics course in the School or College of Education; 50% required students to take one or more required courses in the Mathematics or Statistics Departments; and a small number (20%) required students to take one or more required courses in the Psychology Department.

QM students' preparation in specific statistical topics and methods. We were interested in learning about the extent to which doctoral students in QM programs received training in specific topics and procedures. We developed a list of procedures which we thought reflected a breadth of statistical procedures, and also included procedures we considered to be more "recent", such as meta-analysis, bootstrapping/jackknifing, multilevel models, and causal models. We then asked faculty to mark those procedures and methods in which most or all of their QM students received training. Results are presented in Table 3.

The data suggest that the majority of QM doctoral students receive training in the "old standards"--ANOVA, multiple regression, and traditional multivariate procedure. The exceptions to this appear to be logistic regression and log-linear models, where about half of the respondents indicated that their QM students receive training. Nonparametric procedures, on the other hand, appear to be less prevalent. Although a more detailed list of nonparametric procedures was not provided, it seems reasonable to use the Kruskall-Wallis test as a benchmark, and to note that only half of the respondents indicated that their QM students received training in this procedure. Finally, in terms of more recent procedures, we see that the majority of programs train their students in meta-analysis (70%), and over one-third of the programs train their students in causal models (50%), jackknifing/bootstrapping (40%), and multilevel models (35%).

Mathematical statistics training and computer skills of QM students. We also asked the faculty to rank the mathematical statistics training and computer skills of most of their QM graduates. We used a 4-point scale with "1" indicating "Weak" skills and "4" indicating "Strong" skills. Results are presented in Table 4. In terms of the mathematical statistics training, faculty ratings were symmetrically distributed, with most of faculty rating their students midway on the scale, either as a '2' (44% of faculty) or as a '3' (44% of faculty). In terms of computer skills, the vast majority (90%) thought their students had "strong" skills in standard data analysis programs such as SAS and SPSS. Faculty's perceptions of student competence in other computer skills--database management and programming--were much more varied.

Comparing the mathematical statistical training of past and present QM graduates. Colleagues have occasionally remarked that they believe that earlier graduates of QM programs were better trained in terms than more recent graduates. We were interested in investigating these kinds of comments, by asking faculty if they thought that doctoral students who had graduated in the last year or two were better prepared or less-well prepared in terms of statistics than students who graduated 5 to 6 years earlier. More specifically, we were interested in knowing if they thought there was a difference over time in QM graduates' abilities to do publishable statistical work. Data from Table 5 does not support the claim that earlier graduates were perceived to be stronger. In fact, none of the faculty indicated that thought that their recent QM students were less-well prepared than graduates from 5 to 6 years prior. Over half of the faculty (60%) thought that there was no difference between past and present graduates, and the remaining 40% believed that recent graduates are better-prepared.

Faculty members' perceptions of QM students' needs for additional statistics and qualitative methods coursework. Finally, we asked faculty members to indicate whether they thought their students could have benefited from additional (probably specialized) statistics coursework and from additional qualitative coursework. Data are presented in Table 6. In terms of statistics, nearly half of the respondents (44%) indicated that they thought that over half of their students could have benefited from 1 to 2 additional courses; whereas 22% indicated that they thought that over half of their students could have benefited from 3 or more additional courses. Few of the respondents (11%) thought that their students could have benefited from additional qualitative coursework.

II. Statistics Preparation of non-QM Doctoral Students in Education

Statistics requirements. For the non-QM doctoral students, our first interest was to see if each institution had a minimal statistics requirement for all doctoral students in education. Descriptive statistics are presented in Table 7. In nearly half of the institutions (43%), students in some programs can graduate without taking a statistics course whereas in 40% of the institutions, students in all programs are required to take at least one statistics course[2],. In only 14% of the institutions is there a uniform 2-course statistics requirement.

We had speculated that students might be taking fewer statistics courses currently, in comparison to previous years, due to the increased prevalence of qualitative research methods. Data in Table 8, however, does not indicate a decreasing trend in statistics enrollment over the past five years. In about one-third of the institutions, students are taking fewer statistics classes, but in an equal number of institutions, they are taking more classes. Finally, data from Table 7 indicate that in only 14% of the institutions is there a uniform qualitative methods requirement.[3]

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[2]Note that this statistic does not provide an estimate of how many students actually graduate without a statistics course in a given institution.
[3]Note that this statistic does not provide an estimate of how many students actually take a qualitative methods course.

Perceived competence with specific statistical procedures. We also asked faculty to rate non-QM doctoral students in terms of their ability to critically read and interpret research articles utilizing specific statistical procedures (see Table 9). In particular, faculty were asked to think about the non-QM doctoral students they had contact with over the past five years, and to indicate whether they thought more than half or less than half of these students would be competent with a particular statistical method. Notice that this question requires a lower threshold of "competence" than a question that might ask about doctoral students' abilities to carry out and analyze research utilizing these procedures. The procedures listed--including ANOVA, OLS regression, MANOVA, and nonparametric rank tests--were not meant to be an exhaustive list of procedures, but rather were selected because we thought they represented a cross-section of "common" and "advanced" statistical methods found in published educational research.

Results indicate that the faculty perceived the students to be most competent with ANOVA: 68% of the faculty thought that more than half of their graduates could critically read an article using ANOVA. Only 38% of the faculty thought that more than half of their graduates could critically read an article using OLS regression. Faculty from only 1 or 2 of the 21 institutions thought that more than half of their students could critically read and interpret articles that utilized more advanced (and less common) procedure, namely MANOVA, log-linear models, nonparametric rank tests, and causal models.

Faculty members' perceptions of graduates' need for additional statistical and qualitative coursework. Faculty members were asked to judge the extent to which they thought that non-QM students who had graduated from their School/College of Education could have benefited from additional statistics coursework. More specifically, faculty were asked to think about the students they had contact with over the past 5 years who had graduated, and to gauge whether more than half or less than half of them would have benefited from additional statistics coursework. Results are shown in Table 10. Virtually all of the faculty thought that more than half of the graduates could have benefited from additional (probably specialized) statistics coursework: 43% of the faculty thought that over half of the graduates could have benefited from 1-2 additional courses, and 48% of the faculty though that at least half of the graduates could have benefited from 3 or more courses. In terms of qualitative methods, the majority of faculty (62%) had no opinion on whether graduates could have benefited from more coursework, and only 2 faculty thought that at least half of the graduates could have benefited.

Discussion

Has this survey accomplished anything useful? Despite the methodological shortcomings discussed previously, we so. Consider first the research findings related to the preparation of doctoral students in QM programs.

Implications of the research on QM doctoral students. For the portion of the survey addressing the preparation of QM students, we offer three main implications for our findings. First, we now have empirical evidence of the nature of the curriculum offered in a sample of QM programs. We found much of this information encouraging because it indicated widespread professional agreement in the way that doctoral students majoring in quantitative methods are trained. For example, almost all of the surveyed programs emphasized traditional data-analytic procedures, trained students to use computer packages, and thought that recent graduates were as well or better trained than earlier graduates.

Another finding of interest was that a number of QM programs offered instruction in more recent or advanced procedures such as meta-analysis, causal models, and jackknifing/bootstrapping. This implies that a number of faculty believe that this kind of training is important enough to incorporate into the curriculum. Another implication of our findings is that their similarity to those of Aiken, West, Sechrest and Reno (1990) suggests that information from the two studies can be combined to draw stronger conclusions and guide future research.

Perhaps the most important implication of our research on QM programs is that the findings offer a platform from which we can ask (and in some cases provide tentative answers to) some important questions in the training of doctoral students in quantitative methods. For example, the answer to the question "What percentage of quantitative methods programs have incorporated newer techniques into their curriculum within the past 10 years?" appears to be about half of those surveyed. In our view, this places our findings in a somewhat less positive light. What accounts for the failure to offer training in these newer techniques? Is it simply the result of constraints on credit hours, too few faculty, or that training students who are not majoring in quantitative methods is now the primary business of many quantitative methods programs and that this has a severe effect on the curriculum? And is it acceptable that virtually none of the surveyed programs required training in qualitative research methods yet prominent research journals in education regularly publish the results of qualitative research studies?

We believe the questions raised above (and others) are important and thus provide directions for additional work in the area of preparing doctoral students in quantitative methods. Perhaps the most obvious work to be done is to widen the participation of QM programs and to obtain information about the kinds of positions taken by graduates. As the statistical education literature has argued, curricula must be responsive to the needs of the institutions and industries hiring graduates. We believe that the emergence of information about the training of students in quantitative methods programs should encourage a dialog among professional educators that is overdue.

Preparing non-QM doctoral students. Now consider the portion of the survey that addresses the preparation of non-QM students. We believe that our research findings are useful in that they provide descriptive information on faculty members' perceptions of doctoral student competence. Specifically, the research findings suggest that a number of QM faculty think that a good portion of non-QM doctoral students are under-prepared to be critical consumers of typical quantitatively-oriented research articles. We found that 31% of the faculty thought that less than half of the non-QM doctoral students could critically read and interpret research articles utilizing ANOVA, and 62% of the faculty thought that less than half of the non-QM doctoral students could critically read and interpret research articles utilizing OLS regression. These two procedures--ANOVA and regression--are fairly common in educational research literature. (Recall the work of Elmore and Woehlke (1988), who found that in AERJ, the predominant statistical method used was ANOVA/ANCOVA, which was used in 35% of the articles coded, followed by multiple correlation/regression, which was used in 24% of the articles.) Moreover, the vast majority of faculty thought that less than half of the non-QM doctoral students could critically read articles utilizing more advanced procedures, namely MANOVA, log-linear models, nonparametric rank tests, and causal models.

These research findings suggest that we may have cause for concern about non-QM doctoral students' preparation in statistics. Educational researchers have a variety of job responsibilities, including guiding their students' research; writing and reviewing research grant proposals; serving as educational research consultants; serving as editorial board members; and conducting research in their area of specialization. If a graduate of a doctoral program in education has difficulty critically reading and evaluating quantitative journal articles, then it seems possible that this graduate may also have difficulty functioning successfully as an educational researcher.

Although these findings on the preparation of non-QM doctoral students are only tentative, they do offer direction for future research and discussion. One line of research suggested by this investigation involves studying faculty members' opinions about <u>why</u> some non-QM doctoral students at their universities are under-prepared in educational statistics and what they think can be done to improve non-QM doctoral students' preparation in educational statistics. Another line of research suggested by this current investigation involves studying editors of educational research journals. Because these editors review so many manuscripts (both publishable and unpublishable), they are in a good position to evaluate the statistical and methodological training of today's educational researchers. In addition of journal editors, it might prove fruitful to study the opinions of the doctoral students themselves regarding the adequacy of their own training. Lastly, the perceptions of non-QM faculty could also be of value in informing a discussion on the statistical preparation of non-QM doctoral students.

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Table 1

Universities Initially Contacted for this Study

1. University of Wisconsin--Madison
2. University of Illinois
3. Ohio State University
4. Stanford University
5. University of Minnesota
6. Indiana University--Bloomington
7. Michigan State University
8. Columbia--Teachers College
9. University of Georgia
10. Pennsylvania State University
11. University of Maryland
12. University of Texas--Austin
13. University of Michigan
14. Arizona State University
15. University of California--Los Angeles
16. University of Washington
17. University of California--Berkeley
18. University of Chicago
19. Harvard University
20. University of Virginia
21. Vanderbilt University--Peabody
22. University of North Carolina
23. University of Florida
24. Florida State University
25. Syracuse University
26. University of Nebraska
28. Virginia Polytechnic
29. SUNY-Buffalo
30. University of Missouri
31. University of Pittsburgh

Note: The final sample consisted of N=21 universities from the above list.

Table 2: Demographics: Quantitative Methods Programs

Quantitative Methods Program Size

•Number of full-time tenured/tenure-track faculty in QM program:

Mean	5.3
Median	5.0
SD	2.3
N	20

•Number of full-time faculty who regularly teach statistics during the academic year:

Mean	3.7
Median	4.0
SD	1.8
N	20

•Number of lecturers and adjunct faculty members who teach statistics in QM program:

Mean	1.4
Median	1.0
SD	2.3
N	20

•Approximate number of doctoral students admitted to QM program each year over past 5 years:

Mean	7.9
Median	4.5
SD	9.3
N	19

Location of Required Statistics Courses* in QM Program (N=20)	**Pct**
School/College of Education	100%
Mathematics/Statistics Department	50%
Psychology Department	10%
Other	5%

Academic Year System (N= 20)	**Pct**
Quarter	20%
Semester	80%

*Note: These percentages add to more that 100 because some programs require courses in a School of Education, for example, and a statistics department.

Table 3
Preparation of Quantitative Methods Doctoral Students (N = 20)

	Percent of Universities Where Most or All QM Program Graduates Receive Training in Topic/Method
ANOVA	
Covariance analysis	100%
Repeated measures designs	95%
Mixed-effects models	95%
Power/sample size calculations	95%
Random-effects models	85%
Nonorthogonal designs	80%
Thorough coverage of multiple comparison procedures	75%
Cell means models	55%
Complex designs (e.g. fractional factorial)	40%
Multiple Regression	
Ordinary least squares estimation	100%
Weighted least squares estimation	70%
Nonlinear-in-the-predictors models	70%
Logistic regression	60%
Nonlinear-in-the-parameters models	35%
Traditional Multivariate Procedures	
Canonical correlation	90%
MANOVA	90%
Discriminant analysis	90%
Factor analysis	85%
Principal Components Analysis	80%
MANCOVA	80%
Log-linear models	50%
Nonparametric Procedures	
Kruskall-Wallis test	50%
Exact tests	45%
Jackknifing/Bootstrapping	40%
Repeated measures tests (e.g. Friedman, Cochran, Hodges-Lehmann block test)	30%
Asymptotic relative efficiency	25%
Rank-transform tests	20%
Other Topics and Procedures	
Matrix algebra	85%
Meta-analysis	70%
Causal Models	50%

Multilevel models/Hierarchical linear models	35%
Times series models	5%

Table 4

Faculty Members Perceptions of the Mathematical/Statistical Training and Computer Skills of Quantitative Methods Program Graduates

	Weak (1)	(2)	(3)	Strong (4)	Mean	SD	N
1. Mathematical/statistics training of most QM graduates.**	1 (6%)	8 (44%)	8 (44%)	1 (6%)	2.5	.71	18
2. Computer skills: Standard data analysis programs (e.g. SAS, SPSS, SYSTAT)	0 (0%)	0 (0%)	2 (10%)	18 (90%)	3.9	.31	20
3. Computer skills: Database management	1 (5%)	6 (30%)	12 (60%)	1 (5%)	2.7	.65	20
4: Computer skills: Programming (e.g. FORTRAN, PASCAL, C)	6 (30%)	4 (20%)	9 (45%)	1 (5%)	2.2	.95	20

**For this question, the anchors were as follows: 4=Strong, perhaps took multiple courses in mathematical statistics, probability theory, would probably be well acquainted with topic such as quadratic forms, Likelihood Ratio Test Principle, Gauss-Markoff Theorem, etc; and 1 = Weak, little or no coursework in mathematical statistics or probability theory.

Table 5

Faculty Members Perceptions of QM Program Graduates' Ability to do Publishable Statistical Work* (N = 20)

	Pct
•Faculty who believe that recent graduates are better prepared than graduates from 5-6 years ago.	40%
•Faculty who believe that recent graduates are less-well prepared than graduates from 5-6 years ago.	0%
•Faculty who believe that there is no difference between recent graduates and graduates from 5-6 years ago.	60%

*Note: "Recent graduates" were defined as people who graduated in the last year or two.

Table 6

Faculty Members' Perceptions of Student Needs for Additional Statistics and Qualitative Methods Coursework for Quantitative Methods Program Doctoral Students (N = 20)

	Faculty Members Who Believe That More Half of Graduates Could have Profited from Additional Course (>50%)	Faculty Members with No Opinion
Statistics Coursework	**Pct**	**Pct**
•1-2 additional (probably specialized) statistics courses (N = 18)	44%	11%
•3 or more additional (probably specialized) statistics courses (N = 18)	22%	17%
Qualitative Coursework		
•1 to 2 additional qualitative methods courses (N = 18)	11%	17%

*Note: Data are in response to the following question: "In hindsight, of the quantitative methods program doctoral students who graduated from your program in the last 5 years, what percent do you think could have profited from (the following additional coursework)?"

Table 7

Coursework Requirements for Doctoral Students in Education who are not in Quantitative Methods Programs

1. Statistics Requirement (N = 21)	**Faculty Selecting Option Pct**
•Students in some programs can graduate without taking a statistics course	43%
•Students in all programs are required to take at least one statistics course	38%
•Students in all programs are required to take at least two statistics courses	14%
•Don't know	5%

2. Qualitative Research Requirement (N = 21)	**Pct**
•Students in some programs can graduate without taking a qualitative methods course	76%
•Students in all programs are required to take at least one qualitative methods course	14%
•Don't know	10%

Table 8

Changes in Statistics Enrollment over the Past Five Years for Doctoral Students in Education who are not in Quantitative Methods Programs

Enrollment Change over the Past Five Years (N = 21)	**Faculty Selecting Option Pct**
•Doctoral students have tended to take fewer statistics courses	33%
•Doctoral students have tended to take more statistics courses	33%
•Doctoral students have tended to take about the same number of statistics courses	24%
•Don't know/No Response	10%

Table 9

Perception of Students' Competence to Critically Read and Interpret Research Articles Utilizing Specific Statistical Procedures for Doctoral Students who are not in Quantitative Methods Programs*
(N = 21)

	Faculty Members Indicating that Less than Half of the Graduates are Competent (<50%)		Faculty Members Indicating that More than Half of the Graduates are Competent (>50%)	
	N	**Pct**	**N**	**Pct**
•ANOVA	8	(31%)	13	(62%)
•OLS regression	13	(62%)	8	(38%)
•MANOVA	19	(91%)	1	(5%)
•Log-linear models	20	(95%)	1	(5%)
•Nonparametric rank tests	19	(91%)	2	(10%)
•Causal models	19	(91%)	1	(5%)

*Note: Data are based on responses to the following questions: "Think about the doctoral students in your School/College of Education who are NOT in your quantitative methods program that you have had contact with over the past 5 years or so--through dissertation committees, classes, consulting, and so forth. Of these non-quantitative students, what percent do you think are competent to critically read and interpret research articles that utilize the following procedures? (1) Less than half, (2) More than half, (3) Can't judge.

Table 10

Faculty Members' Perceptions of Graduates' Needs for Additional Statistics and Qualitative Methods Coursework for Doctoral Students who are not in Quantitative Methods Programs (N = 21)

	Faculty Members Who Believe That More Half of Graduates Could have Profited from Additional Coursework (>50%)
Statistics Coursework	**Pct**
•1-2 additional (probably specialized) statistics courses (N = 21)	43%
•3 or more additional (probably specialized) statistics courses (N = 21)	48%
Qualitative Coursework**	
•1 to 2 additional qualitative methods courses (N = 21)	10%

*Note: Data are in response to the following question: "Think about the doctoral students in your School/College of Education who are NOT in your quantitative methods program that you have had contact with over the past 5 years or so--through dissertation committees, classes, consulting and so forth. Of these non-quantitative students, what percent do you think could have profited from (the following additional coursework)".

** For this question, 13 faculty members had no opinion.

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