DATA ANALYSIS KNOWLEDGE AMONG PRESERVICE ELEMENTARY EDUCATION TEACHERS ®

Cynthia S. Thomas
Ball State University
USA

This study investigated whether elementary education majors in the teacher education program at Montana State University (MSU) acquire and retain knowledge of statistical data analysis concepts and skills consistent with expectations specified in the NCTM "Principles and Standards for School Mathematics" (2000). The following statistical topics were covered: Finding, describing and interpreting mean, median and mode; interpreting the spread of a set of data; understanding the meaning of the shape and features of a graph; comparing centers, spreads, and graphical representations of related data sets; and using scatter plots and lines of best fit.

PURPOSE

The purpose of this study was to answer the question "To what degree do university students acquire and retain the statistical data analysis content required for elementary and middle school as defined by the National Council of Teachers of Mathematics?"

BACKGROUND

Today's candidate teachers who will become instructors in grades 5-8 often have the same mathematics background as those who will become teachers in grade K-4, yet they are expected to teach more complex content. The additional challenges inherent in the more ambitious curricular material often require them to be more like mathematics specialists than their original training may have prepared them to be. Furthermore, these teachers often have had little exposure to some of the mathematical ideas that ambitious curricula will require them to teach. Teaching mathematics and statistics in ways that make it understandable by students requires deep, flexible knowledge on the part of the teacher. "Students need to know about data analysis and related aspects of probability in order to reason statistically – skills necessary to becoming informed citizens and intelligent consumers" (National Council of Teachers of Mathematics, 2000 p. 48). To be effective, teachers must know their subject matter so thoroughly that they can present it in a challenging, clear, and compelling way (NCATE, 1998). The National Council of Teachers of Mathematics (NCTM) offers detailed recommendations for teaching statistics in grades K-12 in both *Curriculum and Evaluation Standards for School Mathematics* (1989) and *Principles and Standards for School Mathematics* (2000).

DATA COLLECTION

Since the MSU Elementary Teacher Education Program is stable in content and format from year to year, student (n=232) characteristics were sampled simultaneously at four different stages of the Teacher Education Program. Students were given a 38-item paper/pencil test that examined their knowledge of elementary statistics applicable to elementary education. The NCTM Standards for Statistics for PreK-8 were treated as the standard by which the statistical data analysis knowledge of elementary education majors was measured. Data was collected during Fall Semester of 1999 in four math-related courses required of Elementary Education majors (Mathematics Content Course 1, Mathematics Content Course 2, Teaching Methods Course, and Student Teaching). Students in the first two courses were predominantly freshmen in their first two semesters of college. Mathematics Content Course 1 is primarily the real number system and algebraic concepts while Mathematics Content Course 2 focuses on geometry, statistics, and probability. The Teaching Methods Course students were juniors or seniors who would student teach within the next two semesters. The final group tested had just completed their student teaching semester.

DATA ANALYSIS AND RESULTS

Two-way ANOVAs and multiple regressions were done to determine if certain independent variables (age, gender, level of high school preparation, number of math/stat classes taken and enrolment in the math option) are related to achievement in statistical data analysis. Data analysis showed that neither age nor gender was related to overall achievement or to achievement in any of the five subtests.

Specifically, this study sought to answer the question "To what degree do MSU students acquire and retain the statistical data analysis content required for elementary and middle school as defined by the National Council of Teachers of Mathematics?" The answer to this question is clear: Whatever gains are achieved in content classes are lost by the end of student teaching (See Figure 1). This conclusion is troubling, given the many research findings and the recommendations of important professional organizations that stress the importance of a strong content knowledge base for classroom teachers. Unfortunately, prospective graduates of the Elementary Education program do not have the knowledge that the *Standards* recommend relative to statistical data analysis. In addition, participants are not uniformly capable in their abilities; there is approximately as much variability among all four groups. There was a significant difference among the achievement means of the students in the four courses. For example, there was a significant difference among means of the four groups in *overall* achievement with respect to statistical data analysis. The mean overall achievement of students in Content Course 1 (19.91) was gathered to be used as baseline data, indicating the statistical data analysis knowledge that students had at the beginning of the elementary education program. A significant increase was observed in the mean of the students who had completed Content Course 2 (25.52). The mean achievement score of students completing the methods class (24.11) fell slightly, but not enough to be statistically significant. However, an upsetting finding of this study was that the mean achievement score of students who completed student teaching (21.65) was significantly lower than of the two preceding courses. As can be seen in the five-point summaries in the box-and-whisker plots in Figure 1, more than seventy-five percent of the students in student teaching scored lower than the upper fifty percent of students in Content Course 2.

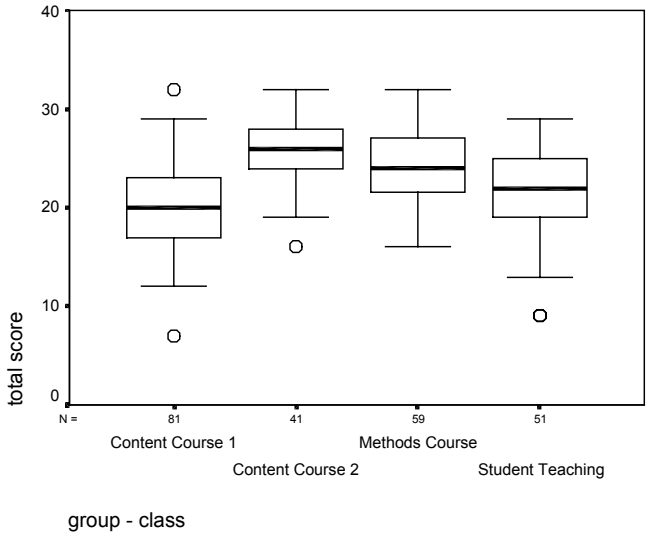

Figure 1. Box-and-Whisker Plots of Total Achievement.

DISCUSSION

While this lack of retention of statistical data analysis knowledge is distressing, it is consistent with the findings of researchers (Darling-Hammond 1999, Schaeffer 1997, Russell 1997, Roberts 1995, Leitzel 1991) in the last decade who found pre-service teachers' mathematical knowledge was weak and rule driven. The teaching profession also recognizes the complexity of preparing teachers. It may be that we can never prepare elementary teachers well enough before they enter the classroom. "In fact, it appears that the new mathematical

understanding teachers must develop and the teaching situation they must negotiate are too varied, complex, and content-dependent to be anticipated in one or even several courses" (Russell, 1997, p 253).

Neither age nor gender was determined to be statistically significant when trying to explain variability in total achievement or achievement in any of the five subtests. These results are consistent with results such as those found by Roberts (1995) who found no significant differences in achievement in geometry and White (1986) who found no significant differences in essential elements of elementary school mathematics.

At MSU, Elementary Education majors who choose to declare a mathematics concentration enroll in the math option. They take eighteen additional credits in Mathematics and Statistics in place of the electives that other elementary education majors are required to take. While the number of students enrolled in the Math Option of the Elementary Education Program in this study was small (n=17), there were enough students to determine if there was a significant difference between the means of those who were enrolled in the option and those who were not. It was troubling to find that there was no significant difference in achievement between the students who were enrolled in the math option and those who were not. There were students who were enrolled in the Math option in each of the four courses.

IMPLICATIONS FOR TEACHER EDUCATION

In light of the findings presented in this study, the following recommendations are offered:

1. Change the timing of the two mathematics content courses in the program sequence. Typically, the students in Content Course 1 and Content Course 2 are freshmen that may not yet have clearly defined their needs as prospective teachers. Perhaps moving the mathematics content courses to the sophomore year would allow the students one more year of thought and maturity in the choice of their career.
2. Have the content and methods integrated within the first three courses (Content Course 1, Content Course 2, and Methods Course) that are required. Courses on subject-matter topics have been disconnected from courses on teaching methods. Students are not making the connections. Darling-Hammond (1999) found that "shoehorning unintegrated courses into the four-year undergraduate program created unhappy trade-offs between deep learning in a disciplinary field and serious understand of teaching and learning" (p.30).
3. Require all elementary education majors to take more specialized mathematics courses. Classes should feature strong mathematics components including course work in geometry, algebra, probability and statistics, basic components of calculus and mathematical modeling (Leitzel, 1991). All concepts should be taught from a conceptual viewpoint rather than from a traditional theoretical point of view (Leitzel, 1991). The statistics courses should be taught using hands-on activities for producing data and illustrating concepts, and using simulation as a device for understanding probability and the basic ideas of inference. Students should see statistics as an organized way to solve problems.

Universities should make continuing statistical education workshops and courses available to all interested elementary teachers. According to Scheaffer (2000), of all the mathematical topics now appearing in elementary curricula, statistics is the newest and ranks at the top in terms of the lack of preparation teachers have to teach this subject matter. Given the lack of knowledge that the current elementary education majors possess when the topic is actively taught within the curriculum, it seems to be obvious that practicing teachers who did not have statistics in their university work are also in need of workshops to increase their knowledge base.

REFERENCES

Darling-Hammond, L. (1999). Educating teachers: The academy's greatest failure or its most important future? *Academe, 85*, 26-33.

Leitzel, J.R.C. (Ed.). (1991). *A call for change: Recommendations for mathematical preparation of teachers of mathematics*. Washington, DC: Mathematical Association of America.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

The National Council for Accreditation of Teacher Education (NCATE). (1998). Technology and the New Professional Teacher: Preparing for the 21st Century Classroom. [On-line] Available at: http://www.ncate.org

Russell, S.J. (1997). The role of curriculum in teacher development. In S.N. Friel and G.W. Bright (Eds.), *Reflecting on our work: NSF teacher enhancement in k-6 mathematics*. New York: University Press of America.

Scheaffer, R.L. (2000). Statistics for a new century. In M. Burke (Ed.), *Learning mathematics for the new century.* Reston, VA: National Council of Teachers of Mathematics.

Roberts, S.K. (1995). A study of the relationship between demographic variables and Van Hiele level of thinking for preservice elementary school teachers. Doctoral Dissertation, Wayne State University. *Dissertation Abstracts International, 57*, 01A: 0176.

White, M.A.F. (1986). Preservice teachers' achievement in the essential elements of elementary school mathematics: The development of an evaluation instrument. Doctoral Dissertation, University of Houston. *Dissertation Abstracts International, 47,* 06A: 2068.