Comparisons of Mathematical Competencies and Attitudes of Elementary Education Majors with Established Norms of a General College Population

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Technology will play an increasingly important role in society as the twenty-first century approaches. In order to be prepared for potential success in the world today and in the future, knowledge of mathematics and science is important, according to Isenberg and Altizer-Tuning (1984). President Bush, in a White House press release (1990), went as far as to state a national goal of turning out students first in the world in mathematics and science by the year 2000, in order to make the United States internationally competitive. The acquisition of the mathematical skills and knowledge begins in elementary school and the teaching of mathematics at this point is a critical factor in the future success of the students. As Schofield (1981) pointed out, elementary teachers must possess sound mathematical competency, as well as positive attitudes toward the subject, in order to be effective teachers.

Dating back to 1949, Glennon provided evidence that those preparing to teach arithmetic in the elementary grades understood only approximately 50% of the computational processes commonly taught in grades one through six. His results showed that preservice teachers did not improve in achievement of basic mathematics understanding during the four years in the teacher education program. In addition, Glennon concluded that even the experience of teaching arithmetic is no guarantee that the teacher will grow in the understanding of mathematics.

In order to produce successful teachers, an examination of the preparation of such teachers is necessary. According to the National Council of Teachers of Mathematics' (NCTM) *Curriculum and Evaluation Standards for School Mathematics* (1989), "Prospective teachers must be taught in a manner similar to how they are to teach--by exploring, conjecturing, communicating, reasoning and so forth. Thus, colleges and mathematical sciences departments should reconsider their teacher preparation programs in light of these curriculum and evaluation criteria" (p. 253).

According to Dossey (1981), the minimum requirements for teacher preparation at college and universities included six hours or less of mathematical content and three hours or less of mathematical methods in the vast majority of the institutions surveyed. Burger, Jenkins, Moore, Musser, and Smith (1983) developed a comprehensive mathematical program based on NCTM's *Agenda for Action* (1980) and concluded that such a program prepared students to better handle the future. As recently as 1990, the Committee on the Mathematical Education of Teachers (COMET) of the Mathematical Association of America recommended a requirement of nine to fifteen hours of mathematics courses for all education majors (Leitzel, 1990). Battista (1986) also found that teachers' mathematical knowledge was significantly related to the learning of mathematical pedagogy as measured in a methods course. The mathematical content received at the post-secondary level does depend upon instruction received in high school, however, and Dossey (1984) indicated that two years of algebra and one year of geometry should be required in high school.

In addition, the evidence indicates that the early educational experiences of many students may lead to mathematical avoidance and a set of negative attitudes (Tobias, 1978). Given this, the results reported in a study by Kelly and Tomhave (1985) are disturbing. The findings revealed that elementary education majors displayed significantly higher levels of mathematics anxiety than other groups, except those in a math-anxious workshop. Trice and Ogden (1987) also found that most math-anxious teachers plan significantly less instructional time for mathematics. In line with this, Schofield (1981) concluded that teachers transmit negative attitudes to pupils which contribute to a decline in student performance.

Based on the available research regarding the effects of the mathematics knowledge and anxiety of elementary teachers on students, it is apparent that future research is necessary to examine the attitude, competency, and background in mathematics of individuals preparing to become elementary school teachers. Therefore, the purpose of conducting this research was to examine the levels of mathematical competencies and attitudes of elementary education majors and to compare these to the competencies and attitudes of students in a general college population.

Method

Course and Subjects

The sample consisted of 171 students enrolled in a mathematics course designed for elementary education majors at a large midwestern university during the fall and spring semesters of the 1988 through 1990 academic years. The 3-

semester hours credit course included a study of arithmetic, geometry, pre-algebra, probability and statistics, and measurement. An emphasis was placed on both practical skills and theoretical understanding. This course was offered exclusively for elementary education majors.

Twelve of the students involved in the study were male, and the ages of the total group ranged from 18 to 57 years with a mean of 24 years and a standard deviation of 8.5. The high school background of the students varied from having only one year of general mathematics (4%) to having four years, including a course in trigonometry and calculus (19%). Ten percent of the sample had taken up to first-year algebra, 30% had received instruction in algebra and geometry, and 37% were previously enrolled in three years of high school mathematics, with the highest level course being second-year algebra.

The mathematical attitudes and competencies of the sample were compared with the established norms from a representative college population. The norms for the mathematical competencies are given by Stones, Beckmann, and Stephens (1982) and the norm for attitude towards mathematics is given by Stones, Beckmann and Stephens (1983). The normative group consisted of 577 males and 477 females enrolled at four state colleges and six 2-year institutions. The mathematics backgrounds of these students varied from no years of high school mathematics (4.7%) to four years of mathematics in high school (24.2%). The breakdown of the courses in which the students were enrolled is contained in Table 1, and class percentages are summarized in Table 2.

Table 1

Percentages of Normative Population Enrolled in Various Mathematics Courses

Mathematics Course	% Enrolled
Applied Mathematics	16.0
Mathematics for Elementary Teachers	14.2
Elementary Algebra	26.4
Intermediate Algebra	23.9
College Algebra	19.5

Table 2

Class Percentages of Normative Population

Classifications	% Population
Freshman	65.5
Sophomore	21.9
Junior	8.8
Senior	3.3
Other	0.5

Among the normative group, 338 attended the 2-year institutions while 716 were enrolled in the 4-year colleges. The mathematical attitudes and competencies of students in the 2-year and the 4-year institutions were not found to be statistically different. The major fields of study of these students varied greatly, and although not all majors were represented, the group was considered to be representative of a general college population. The mathematics courses for which they were enrolled generally fulfilled the mathematics requirements of their respective programs.

Instruments

Mathematical competency was determined by the score the student received on the *Beckmann-Beal Mathematical Competencies Test for Enlightened Citizens, Form A*. The test consisted of 48 questions with one question related to each of the competencies given in the 1972 report of the National Council of Teachers of Mathematics (Edwards, 1972). A total score of 48 was possible on the test with sub-scores for each of 10 sub-categories, including: (a) numbers and numerals, (b) operations and properties, (c) mathematical sentences, (d) geometry, (e) measurement, (f) relations and functions, (g) probability and statistics, (h) graphing, (i) mathematical reasoning, and (j) business and consumer mathematics. The reliability and validity of the instrument were found to be satisfactory (Matthews, 1974).

The mathematics attitudes of students were indicated by the score of the *Revised Math Attitude Scale* (Aiken, 1963). The opinionnaire was a 20-item scale with Likert-type scoring. The maximum score was 80, which was indicative of an extremely positive attitude toward mathematics. The minimum score possible was zero, which was indicative of an extremely negative attitude toward mathematics. A score of 40 indicated a neutral attitude toward mathematics. A test-retest reliability coefficient of 0.94 for the instrument was reported by Aiken and Dregger (1961), and the validity was found to be satisfactory.

Procedure

At the outset of each semester, the two instruments were administered to all students enrolled in the course. In addition, demographic information was collected regarding sex, age, and mathematics courses taken in high school. The results of the attitude and competency instruments were used to compare the mathematical attitudes and competencies of the elementary education majors with previously established norms of a general college population.

Statistical Analysis

A data file consisting of the scores on all measures for the 171 students was compiled. The SAS statistical package was implemented to analyze the data. Attitudes and competencies in mathematics of the sample were compared with the norms established for the general college population by use of the *t*-

test. Pearson's correlation coefficients were calculated to investigate the relationships between age, years of high school mathematics, attitude, competency, and achievement of the elementary education majors. The measure of achievement in mathematics was determined at each semester's conclusion. Students' scores in the course were calculated based on the percentage of total points earned on tests and projects throughout the semester.

Results

Elementary education majors were shown to possess more negative attitudes toward mathematics than the general college sample and lower levels of mathematical competency as shown in Table 3. The mean attitude score for the elementary education majors was 36.63, indicating a slightly negative attitude toward mathematics compared with a neutral score of 40. The norm attitude score was 45.39, indicating a more positive attitude toward mathematics. The difference between the sample mean and the norm was found to be statistically significant ($p < .001$). Similarly, the mean score of 32.63 on mathematical competency for the elementary education majors was significantly lower than the norm of 35.7 ($p < .001$). Due to absences, the number of students taking the competency test dropped to 165.

The mean scores on the 10 sub-categories of the competency instrument for the sample group are also reported in Table 3. This table reveals that the elementary education majors scored lower than the established norms of the general population in nine categories, all areas except that of mathematical reasoning, with a highly significant difference ($p < .001$) in eight of the sub-categories.

In an effort to examine the factors related to the mathematical competencies and attitudes within the sample of elementary education majors, the Pearson correlation coefficients were calculated between age, years of high school mathematics, mathematics attitude, competency and achievement, as contained in Table 4. Significant positive correlations were found to exist between years of high school mathematics and (a) attitude ($r = .40$), (b) competency ($r = .27$), and (c) achievement ($r = .19$).

Table 4

Correlation Coefficients Between Age, Years of High School Mathematics, Mathematics Attitude, Mathematical Competency and Achievement for Elementary Education Majors

	Years of HS Math	Attitude	Competency	Achievement
Age	-.30	.05	.23	.28
	.0001	.5000	.0060	.0002
	(170)	(170)	(147)	(167)
Years of HS Math		.40	.27	.19
		.0001	.0009	.0133
		(171)	(148)	(168)
Attitude			.34	.30
			.0001	.0001
			(148)	(168)
Competency				.59
				.0001
				(153)

first value = correlation coefficient, second value = p-value, third value = sample size

Table 3

Comparisons of Mathematics Competencies and Attitude Toward Mathematics of Elementary Education Majors to Established Norms

Measure	Mean	SD	Norm	t-value
Total Mathematics Competency	32.63	6.73	35.70	-5.86**
Numbers & Numerals	5.30	1.29	5.48	-1.79*
Operations & Properties	5.70	1.46	6.30	-5.28**
Mathematical Sentences	1.94	0.80	2.22	-4.50**
Geometry	3.33	1.27	3.77	-4.45**
Measurement	3.32	0.91	3.78	-6.49**
Relations & Functions	1.58	0.81	2.07	-7.77**
Probability & Statistics	2.01	0.99	2.22	-2.72*
Graphing	2.78	0.95	3.10	-4.33**
Mathematical Reasoning	2.47	0.64	2.21	5.22**
Business & Consumer Mathematics	4.21	1.20	4.54	-3.53**
Attitude Toward Mathematics	36.63	19.46	45.39	-5.78**

* $p < .05$
** $p < .001$

Mathematical competency and achievement were both found to correlate positively with attitude toward mathematics, with correlation coefficients of .34 and .30, respectively ($p < .001$).

Conclusion

The findings of this study indicate that the elementary education majors possessed deficits in almost all knowledge and content areas in mathematics when compared with the established norms of a general college population. Poorer attitudes than the general college students toward mathematics were also displayed. The mean attitude scores recorded by the elementary education majors reflected that the attitudes were slightly negative in nature. Together, the low competency levels and poor attitudes toward mathematics among preservice elementary teachers create an area of concern.

The correlational analysis revealed that years of high school mathematics was highly related to both the attitude and competency in mathematics of elementary education majors. As had previously been put forth by Dossey (1984), these findings, although not proving causality, may suggest that increased requirements at the secondary level may improve competency and, possibly, attitudes. Finally, attitude, competency, and years of high school mathematics were all found to be significantly related to achievement in a mathematics course.

These results are disturbing in light of the research suggesting that elementary teachers affect both achievement and attitude of students in mathematics (Schofield, 1981). Indeed, elementary teachers have been found to play an important role in the early development of a mathematical environment for students but have simultaneously regarded mathematics as a necessary evil (Bulmahn & Young, 1982).

Recommendations previously stated, that colleges of education require additional hours of mathematics for elementary education majors (Burger et al., 1983; Dossey, 1984; Leitzel, 1990), should be considered based on the results of this study. In addition, prerequisites of at least three years of high school mathematics, including second-year algebra, could improve both the mathematical competencies and attitudes of those preparing to be elementary school teachers. Since both attitudes and competencies in mathematics were found to be low among the sample, priority should be placed on implementation of these recommendations.

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