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MIDDLE AND HIGH SCHOOL MATHEMATICS TEACHER DIFFERENCES IN MATHEMATICS ALTERNATIVE CERTIFICATION

Brian R. Evans
Pace University, bevans@pace.edu

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Brian Evans, Pace University

Abstract

This study examined the differences in content knowledge, attitudes toward mathematics, and concepts of teacher self-efficacy among several different types of teachers in the New York City Teaching Fellows program, and informs teacher education in mathematics alternative certification. Findings revealed that high school teachers had significantly higher content knowledge than middle school teachers. Mathematics Teaching Fellows had significantly higher content knowledge than Mathematics Immersion Teaching Fellows. Mathematics and science majors had significantly higher content knowledge than other majors. Teachers had the same high positive attitudes toward mathematics and same high concepts of self-efficacy regardless of content ability.

Introduction

The purpose of this study was to determine differences in content knowledge, attitudes toward mathematics, and concepts of teaching self-efficacy among different categories of alternative certification teachers in New York City. The teachers in this study come from two mathematics methods sections of New York City Teaching Fellows (NYCTF) teachers. The NYCTF program was developed in 2000 in conjunction with The New Teacher Project and the New York City Department of Education (NYCTF, 2008; Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2007). The program goal was to recruit professionals from other fields to supply the large teacher shortages in New York City's public schools.

Background and Theoretical Framework

Recently there has been an interest in studying the effects of alternative teacher certification programs in U.S. classrooms with a particular interest in teacher quality issues in the NYCTF program (Boyd, Grossman, Lankford, Loeb, Michelli, & Wyckoff, 2006; Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2006; Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2007; Cicchelli & Cho, 2007; Costigan, 2004; Stein, 2002). Previous research found that teachers prepared in alternative certification programs, such as the Teaching Fellows program, have on average higher test content scores than other teachers (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2006; Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2007). However, details about content knowledge have been sparse and there has been a lack of concentrated focus on mathematics teachers specifically. Most studies investigated teacher retention and student achievement as variables to determine success. These are two of the most important variables, but there is a need to investigate other variables related to success, such as teacher content knowledge, attitudes toward mathematics, and teacher self-efficacy. Humphrey and Wechsler (2007) called for more research into alternative certification pathways: "Clearly, much more needs to be known about alternative certification participants and programs and about how alternative certification can best prepare highly effective teachers" (p. 512). Humphrey and Wechsler said more research is needed into teacher backgrounds. This study expanded upon the literature by determining differences between several variables for Teaching Fellows.

Aiken (1970) and Ma and Kishor (1997) found a small but positive significant relationship between achievement and attitudes. This relationship between achievement and attitudes, along with Ball, Hill, & Bass' (2005) emphasis on the importance of content knowledge for teachers, formed the framework of this study. Additionally, Bandura's (1986) construct of self-efficacy theory framed the study's focus on self-efficacy. Bandura found that teacher self-efficacy can be subdivided into a teacher's belief in his or her ability to teach effectively, and his or her belief in affecting student learning outcomes. Teachers who feel that they cannot effectively teach mathematics and affect student learning are more likely to avoid teaching from an inquiry student-centered approach with real understanding (Swars, Daane, & Giesen, 2006).

Research Questions

1. Are there differences in mathematical content knowledge, attitudes toward mathematics, and concepts of teacher self-efficacy between middle and high school Teaching Fellows?
2. Are there differences in mathematical content knowledge, attitudes toward mathematics, and concepts of teacher self-efficacy between Mathematics and Mathematics Immersion Teaching Fellows?
3. Are there differences in mathematical content knowledge, attitudes toward mathematics, and concepts of teacher self-efficacy between undergraduate college majors among the Teaching Fellows?

Methodology

The sample in this quantitative study consisted of 42 new teachers in the Teaching Fellows program from two sections of mathematics methods that involved a combination of both pedagogical and content instruction. The course focused on constructivist methods with an emphasis on problem solving and real-world connections. Teaching Fellows were labeled as Mathematics or Mathematics Immersion students based upon having 30 or more mathematics content credits before entering the program. Mathematics Teaching Fellows have the required minimum 30 credits, while Mathematics Immersion Teaching Fellows do not.

Teaching Fellows were given a mathematics content test and two questionnaires at the beginning and end of the semester. The mathematics content test consisted of 25 free response items ranging from algebra to calculus. Additionally, mathematics Content Specialty Test (CST) scores for the New York State certification were recorded as another measure of mathematical content knowledge.

The first questionnaire was created by Tapia (1996) and has 40 items that measured attitudes toward mathematics including self-confidence, value, enjoyment, and motivation in mathematics using a 5-point Likert scale. The second questionnaire was adapted from the Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) developed by Enochs, Smith, and Huinker (2000), and measured concepts of self-efficacy with 21-items using a 5-point Likert scale instrument. It is grounded in the theoretical framework of Bandura's self-efficacy theory (1986), and is based on the Science Teaching Efficacy Belief Instrument (STEBI-B) developed by Enochs and Riggs (1990), the MTEBI contains two subscales: Personal Mathematics Teaching Efficacy (PMTE) and Mathematics Teaching Outcome Expectancy (MTOE) with 13 and 8 items, respectively. Possible scores range from 13 to 65 on the PMTE, and 8 to 40 on the MTOE. The PMTE specifically measures a teacher's self-concept of his or her ability to effectively teach mathematics. The MTOE specifically measures a teacher's belief in his or her ability to directly affect student learning outcomes.

Results

The first research question was answered using independent samples *t*-tests comparing middle and high school teacher data using the 25-item mathematics content test, 40-item attitudinal test, and 21-item MTEBI with two subscales: PMTE and MTOE. The results of the independent samples *t*-test for the first part of research question one revealed a statistically significant difference between middle school teacher scores and high school teacher scores for the mathematics content pretest (see Table 1). Additionally, there was a large effect size. The results of the independent samples *t*-test for the first part of research question one also revealed a statistically significant difference between middle school teacher scores and high school teacher scores for the mathematics content posttest (see Table 1). Additionally, there was a large effect size. This means high school teachers had higher content test scores than middle school teachers on the pre- and posttests. For attitudes toward mathematics and concepts of self-efficacy there were no statistically significant differences found between middle and high school teachers on both pre- and posttests.

Table 1

Independent Samples t-Test Results on Mathematics Content Test

Assessment	Mean	SD	*t*-value	Effect Size
Mathematics Content Pre-Test				
Middle School (N =26)	68.42	15.600	-3.334**	1.056
High School (N = 16)	85.13	16.041		
Mathematics Content Post-Test				
Middle School (N =26)	79.46	15.402	-3.230**	1.112
High School (N = 16)	92.63	6.582		

$N = 42$, $df = 40$, two-tailed

** $p < 0.01$

The second research question was answered using independent samples *t*-tests comparing Mathematic Immersion and Mathematics Teaching Fellows data also using the 25-item mathematics content test, 40-item attitudinal test, and 21-item MTEBI with two subscales: PMTE and MTOE. The results of the independent samples *t*-test for the first part of research question two revealed a statistically significant difference between Mathematics Immersion Teaching Fellows' scores and Mathematics Teaching Fellows' scores for the mathematics content pretest (see Table 2). Additionally, there was a large effect size. The results of the independent samples *t*-test for the first part of research question two also revealed a statistically significant difference between Mathematics Immersion Teaching Fellows' scores and Mathematics Teaching Fellows' scores for the mathematics content posttest (see Table 2). Additionally, there was a large effect size. This means Mathematics Teaching Fellows had higher content test scores than Mathematics Immersion Teaching Fellows on the pre- and posttests. For attitudes toward mathematics and concepts of self-efficacy there were no statistically significant differences found between Mathematics and Mathematics Immersion Teaching Fellows on both pre and posttests.

Table 2

Independent Samples t-Test Results on Mathematics Content Test

Assessment	Mean	SD	*t*-value	Effect Size
Mathematics Content Pre-Test				
Mathematics (N = 12)	89.50	7.868	-4.005**	1.555
Mathematics Immersion (N = 30)	68.90	17.008		
Mathematics Content Post-Test				

Mathematics ($N = 12$)	94.33	7.390	-3.130**	1.202
Mathematics Immersion ($N = 30$)	80.53	14.460		

$N = 42$, $df = 40$, two-tailed

** $p < 0.01$

The third research question was answered using one-way ANOVA comparing different undergraduate college majors also using the 25-item mathematics content test, 40-item attitudinal test, and 21-item MTEBI with two subscales: PMTE and MTOE. Teaching Fellows were grouped according to their undergraduate college major. Three categories were used to group teachers: liberal arts ($N = 16$), business ($N = 11$), and mathematics and science ($N = 15$) majors. The results of the one-way ANOVA for the first part of research question three revealed a statistically significant difference on the mathematics content pretest (see Tables 3 and 4). A post hoc test (Tukey HSD) was performed to determine exactly where the means differed. The post hoc test revealed that mathematics and science majors had significantly higher content knowledge on the pretest than business majors, $p = 0.001$ and liberal arts majors, $p = 0.008$. There were no other statistically significant differences. The results of the one-way ANOVA for the first part of research question three also revealed a statistically significant difference on the mathematics content posttest (see Tables 3 and 5). Again, a post hoc test (Tukey HSD) was performed to determine exactly where the means differed. The post hoc test revealed that mathematics and science majors had significantly higher content knowledge on the posttest than business majors, $p = 0.005$ and liberal arts majors, $p = 0.025$. There were no other statistically significant differences. It was concluded that mathematics and science majors had statistically significant higher content knowledge scores on both pre and posttests than non-mathematics and non-science majors. For attitudes toward mathematics and concepts of self-efficacy there were no statistically significant differences found between the undergraduate college majors on both pre and posttests.

Table 3

Means and Standard Deviations on Content Knowledge

Pre-, Post-, and CST Tests	Mean	Standard Deviation
Content Knowledge Pre Test		
Liberal Arts (*N* = 16)	70.13	16.382
Business (*N* = 11)	64.45	15.820
Math/Science (*N* = 15)	87.33	12.804
Total (*N* = 42)	74.79	17.605
Content Knowledge Post Test		
Liberal Arts (*N* = 16)	81.19	15.132
Business (*N* = 11)	76.82	14.034
Math/Science (*N* = 15)	93.60	7.679
Total (*N* = 42)	84.48	14.225
CST Content Knowledge		
Liberal Arts (*N* = 16)	255.81	18.784
Business (*N* = 11)	249.64	18.943
Math/Science (*N* = 15)	273.80	15.857
Total (*N* = 42)	260.62	20.184

Table 4

ANOVA Results on Mathematics Content Pretest for Major

Variation	Sum of Squares	*df*	Mean Square	*F*
Between Groups	3883.261	2	1941.630	8.582**
Within Groups	8823.811	39	226.252	
Total	12707.071	41		

** $p < 0.01$

Table 5

ANOVA Results on Mathematics Content Posttest for Major

Variation	Sum of Squares	*df*	Mean Square	*F*
Between Groups	2066.802	2	1033.401	6.469**
Within Groups	6229.674	39	159.735	
Total	8296.476	41		

** $p < 0.01$

Since significant differences were only found for content knowledge, as measured by the 25-item mathematics content test, it was decided that a focus on content knowledge differences would be appropriate using another other content instrument. The first part of each research question was addressed again by using scores on the CST. It was found using an independent samples *t*-test that high school teachers had statistically significant higher content knowledge than middle school teachers as measured by CST scores (see Table 6). Additionally, there was a moderate effect size. Further, it was found using an independent samples *t*-test that Mathematics Teaching Fellows had statistically significant higher content knowledge than Mathematics Immersion Teaching Fellows as measured by CST scores (see Table 6). Additionally, there was a large effect size.

Table 6

Independent Samples t-Test Results on Mathematics Content Specialty Test (CST)

Assessment	Mean	SD	*t*-value	Effect Size
Mathematics CST				
Middle School (*N* =26)	255.31	20.372	-2.283*	0.741
High School (*N* = 16)	269.25	17.133		
Mathematics CST				
Mathematics (*N* = 12)	276.33	16.104	-3.636**	1.277
Mathematics Immersion (*N* = 30)	254.33	18.291		

$N = 42$, $df = 40$, two-tailed

* $p < 0.05$, ** $p < 0.01$

Teaching Fellows were again grouped according to their undergraduate college majors. The results of the one-way ANOVA revealed a statistically significant difference for the CST scores (see Tables 3 and 7). A post hoc test (Tukey HSD) was performed to determine exactly where the means differed. The post hoc test revealed that mathematics and science majors had significantly higher content knowledge, as measured by the CST, than business majors, $p = 0.004$ and liberal arts majors, $p = 0.021$. Again, it can be concluded that mathematics and science majors had statistically significant higher content knowledge scores than non-mathematics and non-science majors, as measured by the CST. There were no other statistically significant differences.

Table 7

ANOVA Results on Mathematics Content Specialty Test (CST) for Major

Variation	Sum of Squares	*df*	Mean Square	*F*
Between Groups	4302.522	2	2151.261	6.765**
Within Groups	12401.383	39	317.984	
Total	16703.905	41		

** $p < 0.01$

Discussion and Implications

In a previous study with the same sample it was found that teachers had positive attitudes toward mathematics and high concepts of self-efficacy. Taking the results of the first study with the results found in this present study, a very interesting finding emerged. Teachers had the same high positive attitudes toward mathematics and same high concepts of self-efficacy regardless of content ability. Thus, teachers believed they were just as effective at teaching mathematics, despite not having the high level of content knowledge that some of their colleagues possessed. This is significant since high content knowledge is a necessary condition for quality teaching (Ball et al., 2005).

This study informs teacher education since it was found that high school teachers, Mathematics Teaching Fellows, and those who majored in mathematics and science had higher mathematics content knowledge on two measures. Since New York State holds the same high standards for both high school and middle teachers alike, strategies to better middle school teachers' content knowledge should be investigated and implemented. It is recommended that middle school teachers be given the support they need in mathematics content knowledge by both the schools in which they teach and the schools of education in which they are enrolled.

In order to make well informed decisions about teacher recruitment and development, more research is necessary on the growing alternative certification segment of the teaching population. Unless something is done to better prepare teachers with the rigorous content they need, having teachers who had not majored in mathematics and science related areas teach mathematics could be a disservice to the many urban students who receive alternative certification teachers.

References

Aiken, L. R. (1970). Attitudes toward mathematics. *Review of Educational Research, 40*(4), 551-596.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing mathematics for teaching: Who knows mathematics well enough to teach third grade, and how can we decide? *American*

Educator, 14-17, 20-22, & 43-46.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs, NJ: Prentice Hall.

Boyd, D. J., Grossman, P., Lankford, H., Loeb, S., Michelli, N. M., & Wyckoff, J. (2006). Complex by design: Investigating pathways into teaching in New York City schools. *Journal of Teacher Education, 57*(2), 155-166.

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2006). How changes in entry requirements alter the teacher workforce and affect student achievement. *Education Finance and Policy, 1*(2), 176-216.

Boyd, D., Lankford, S., Loeb, S., Rockoff, J., & Wyckoff, J. (2007). The narrowing gap in New York City qualifications and its implications for student achievement in high poverty schools. National Center for Analysis of Longitudinal Data in Education Research.

Cicchelli, T., & Cho, S. (2007). Teacher multicultural attitudes: Intern/Teaching Fellows in New York City. *Education and Urban Society, 39*(3), 370-381.

Costigan, A. (2004). Finding a name for what they want: A study of New York City's Teaching Fellows. *Teaching and Teacher Education: An International Journal, 20*(2), 129-143.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale. *School Science and Mathematics, 90,* 695-706.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the Mathematics Teaching Efficacy Beliefs Instrument. *School Science and Mathematics, 100*(4), 194-202.

Humphrey, D. C., & Wechsler, M. E. (2007). Insights into alternative certification: Initial findings from a national study. *Teachers College Record, 109*(3), 483-530.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education, 28*(1), 26-47.

New York City Teaching Fellows. Retrieved August 26, 2008, from http://www.nyctf.org/.

Stein, J. (2002). Evaluation of the NYCTF program as an alternative certification program. New York: New York City Board of Education.

Swars, S. L., Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106*(7), 306-315.

Tapia, M. (1996). *The attitudes toward mathematics instrument*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Tuscaloosa, AL.