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Effects of Teacher Qualifications on Student Achievement in Middle School Mathematics in
Texas

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Introduction

Few educators, economists, or politicians would argue with the contention that, all other things being equal, highly qualified teachers produce greater student achievement than comparatively less qualified teachers. Indeed, Ferguson (1991, p. 465) concluded from his research in Texas and elsewhere, "Good teachers have distinguishable impacts on student exam scores." Likewise, William Sanders (1998) found that the "single largest factor affecting academic growth of populations of students is differences in effectiveness of individual classroom teachers" (p. 27). Concomitant to this growing consensus that highly skilled teachers are the key to improving student achievement is the realization that a substantial number of teachers appear to be underqualified for their current teaching positions (Ingersoll, 1999). Consequently, as noted by Ingersoll (p. 26), "Few educational problems have received more attention in recent times than the failure to ensure that our nation's elementary and secondary classrooms are all staffed by qualified teachers." This attention culminated in the passage of the No Child Left Behind Act (NCLB) of 2001 that requires states to have a "highly qualified" teacher in every classroom by the end of the 2005–2006 academic year.

Many states, however, are faced with a shortage of qualified teachers (Ingersoll, 1999). In response, states have continued to allow underqualified teachers entry into the profession as a means to reduce the shortage (Laczko-Kerr & Berliner, 2002). Thus, while states are forced to increase teacher quality through NCLB, they concomitantly use various strategies to allow underqualified teachers into the field. One strategy supported by the U.S. Department of Education is to allow individuals enrolled in alternative certification programs to be designated

as highly qualified before they obtain full state certification. In Texas, the number of teachers employed on an alternative certificate has increased from about 3,000 in 1994 to over 10,000 each year since 2002 (Fuller, 2002). Other strategies utilized in Texas and other states that allow uncertified teachers into the classroom are out-of-state certificates, temporary certificates, emergency certificates, and district permits.

The impending deadline for meeting the NCLB requirement that every classroom in the core content areas be staffed with a highly qualified teacher underscores the importance of research on the effectiveness of uncertified and certified teachers. Without such research, we could be—as many have argued—actually reducing the quality of teachers under NCLB (Berry, 1995).

Teacher characteristics such as certification, content knowledge, pedagogical knowledge, years of teaching experience, and assignment in-field have been investigated to determine their effect on student outcomes. However, no previous study has used student-level data from a system aligned around one set of standards, such as that implemented in Texas in 1994. In Texas, the state-mandated tests are tightly aligned with the state-mandated curriculum and administered every year.

Review of the Literature

Licensure and Certification

Teacher certification was implemented to ensure that every teacher possesses the requisite knowledge and skills to instruct students. Essentially, certification is designed to protect the public from harm by identifying which teachers do and do not possess the qualities necessary to teach. Certification, however, is different from the licensure structure for some other professions such as cosmetology, law, and medicine (Laczko-Kerr & Berliner, 2002). In other

professions, practitioners must possess a license in order to practice (Pyburn, 1990). However, no such requirement is in place within the education profession. Thus, uncertified individuals still legally may be employed as teachers. As a result, states are allowed to issue a host of emergency and other certificates that allow individuals to teach even though they are not “fully” certified by the state.

These certification requirements differ substantially from state to state. The preparation program content, requirements for certification, and certification examinations differ. Some states require only an exam upon entering a teacher preparation program, others only test on content once a program is completed, and still others require both a content and pedagogy exam for certification. As a result, even the term *certification* can mean very different things.

Due to certification requirements and the ability of states to issue a host of emergency and other certificates, large numbers and percentages of teachers are certified but are actually underqualified. In Texas, between 30,000 and 35,000 Texas public school teachers were not fully certified in each year since 2000 (Fuller, 2004). In California, the number of teachers without a full certificate has declined from approximately 42,000 in 2001 to only 28,000 in 2004 (Esch, Chang-Ross, Guha, Tiffany-Morales, & Shields, 2004). These and many other states have a substantial number and percentage of teachers teaching without a full state certificate (Laczko-Kerr & Berliner, 2002). In Texas and California, teachers without full certificates are disproportionately located in schools serving large percentages of poor and minority students (Esch et al., 2004; Fuller, 2004).

Proponents of teacher certification standards purport that specific teacher characteristics such as certification and academic major are associated with increased gains in student achievement (Darling-Hammond, 2000). Others declare the available research does not support

specific rigorous teacher preparation and certification standards. Two recent works stated that teacher certification requirements do not effect student achievement, but do raise barriers that prevent qualified applicants from entering the profession (Ballou & Podgursky, 2000a, 2000b). There is, as shown below, little agreement on the association between student achievement and a number of teacher characteristics related to the issue of certification.

Subject-Matter Preparation

One concern regarding underqualified teachers is how well they know the subject matter that they are assigned to teach. In general, teachers on emergency permits as well as those on alternative certificates may or may not have demonstrated subject-matter knowledge through a major or minor or through passing a certification test. Many have argued that many fully certified teachers have not demonstrated subject-matter knowledge either because they obtained an education degree rather than a subject-matter degree or because in the past many teachers were not required to pass a subject-matter state examination.

Although one might assume the literature base establishing a positive relationship between a teacher's subject-matter knowledge and increased student achievement is both voluminous and consistent, Wilson, Floden, and Ferrini-Mundy (2001) found that the research base in this area is, in fact, relatively small and certainly not consistent. Indeed, Wilson et al. stated, "The conclusions of these few studies [on the connection between subject-matter preparation and student achievement] are provocative because they undermine the certainty often expressed about the strong link between college study of a subject matter and teacher quality" (p. 6). In their review, Wilson et al. found only a few studies that examined teacher preparation, subject-matter knowledge, and student achievement that met their rigorous criteria for inclusion in their review.

In general, researchers have found that possessing a major or minor in mathematics or science is related to increased student achievement in these subject areas. Goldhaber and Brewer (2000) found that students with teachers with degrees in mathematics had greater gains in achievement than students with teachers with nonmathematics degrees, but the researchers found no such results for science. In a previous study, Goldhaber and Brewer (1996) found that subject-specific training in mathematics and science has a significant and positive impact on student achievement in these areas. This suggests that greater subject-matter knowledge is associated with gains in student achievement, albeit only in the areas of mathematics and science.

Also with respect to degree level, Ehrenberg and Brewer (1994) found that the percentage of teachers with at least a master's degree was associated with greater achievement for African American students in mathematics, reading, and vocabulary. Likewise, Ferguson (1991) found that the percentage of teachers with master's degrees in Texas was positively associated with student achievement gains at the district level. Alternatively, using Texas data as well, Rivkin, Hanushek, and Kain (2002) stated that master's degrees are not related to teacher effectiveness. However, the authors only examined the scores at the elementary grades.

Again, looking at mathematics, Rowan, Chiang, and Miller (1997) found that students taught by teachers with a mathematics major had greater gains in student achievement, although the effect on student achievement was rather small. Likewise, Wenglinsky (2002) found that mathematics and science teachers with an undergraduate minor or major in their field elicited greater gains in student performance. In fact, Wenglinsky noted, "Students whose teachers majored or minored in the subject area that they are teaching outperform their peers by about 40% of a grade level in both math and science." (p. 7). While not directly investigating the effect of an undergraduate degree, Hawk, Coble, and Swanson (1985) found that students with

mathematics teachers assigned in-field and who possessed a major or minor in mathematics scored higher and had greater gains than students with mathematics teacher's assigned out-of-field and who did not have a major or minor in mathematics.

In a comprehensive study, Monk (1994), found that undergraduate coursework in mathematics was positively related to student improvement in mathematics, but that having a mathematics major had no effect or a negative effect on student performance. However, when examining the effect on students by their type of course, Monk found that additional undergraduate mathematics courses did positively impact student achievement for students in advanced courses, but had no effect on student achievement for students in remedial courses. With respect to the life sciences, Monk found that coursework had no effect on student achievement. With respect to undergraduate coursework in the physical sciences, he found a positive relationship between the number of courses and gains in student achievement. Interestingly, unlike with mathematics, having a science major was positively associated with gains in student achievement.

In a review of the literature, Byrne (1983) reviewed 30 studies that focused on the relationship between subject-matter knowledge and student achievement. A slight majority of the studies showed a positive relationship, while the remainder did not. Druva and Anderson (1983) also completed a comprehensive review of the literature available at the time and concluded that there is a positive relationship between teachers' science coursework and student performance, especially for students in higher level courses.

Using a slightly different measure of subject-matter knowledge, Strauss and Sawyer (1986) used National Teacher Examination (NTE) scores as an indication of subject-matter knowledge. Specifically, they examined the relationship between district aggregate NTE scores

of North Carolina teachers and district-level student performance. Once the researchers controlled for things such as student demographics, they found that teacher scores on the NTE and student performance were strongly and positively associated. They found that as teachers' test scores increased, students' failure rates on high school competency examinations decreased.

Darling-Hammond (2000) found that the percentage of teachers with both a subject-matter major and full state certification was positively associated with a state's reading and mathematics scores on the National Assessment of Educational Progress (NAEP). A more recent analysis by Wenglinsky (2000) used multilevel structural equation modeling to analyze data from the NAEP and found that teachers with a major or minor in the subject area that they are assigned to teach produce greater gains in student achievement in both mathematics and science.

The overall findings from these studies suggest that teacher subject-matter knowledge positively influences student achievement. Moreover, this effect seems to be more pronounced for the upper grades than the lower grades. The research, however, is not consistent. Some studies showed no effect for teacher subject-matter knowledge. In addition, the majority of studies focused on mathematics and science teachers. Thus, far less is known about teachers of English language arts, social studies, and other disciplines.

Pedagogical Preparation

Interestingly, NCLB emphasizes the importance of subject-matter knowledge but largely ignores the role of pedagogical knowledge in developing effective teachers. Clearly, those instrumental in writing NCLB believed that pedagogy could not be learned in teacher preparation programs, but rather through on-the-job training. On the other hand, many education experts strongly contend that subject matter is necessary but not sufficient in developing effective teachers. They argue, rather, that teachers also must have pedagogical knowledge in order to

teach students well. In general, uncertified teachers have had much less pedagogical training—either in a preparation program or in a classroom—than fully certified teachers. Again, as with content knowledge, the research is contradictory.

Monk (1994) found that, in many cases, undergraduate coursework in mathematics pedagogy contributed more to gains in student achievement than did undergraduate coursework in mathematics. He also found that undergraduate coursework in science pedagogy was positively associated with student achievement for students in Grade 11 and that graduate coursework in science pedagogy was positively associated with student performance in Grade 10. Ferguson and Womack (1993), measuring teacher effectiveness through supervisor evaluations, found that education coursework explained a greater proportion of the variation in evaluations than did content knowledge as measured by standardized test scores. Indeed, education coursework explained 16% of the variance in the evaluations.

In their review of the literature at that time, Ashton, Crocker, and Olejnik (1986) found education coursework to be positively associated with student achievement. Likewise, in a meta-analysis of 65 studies on the relationship between science teacher preparation and student achievement, Druva and Anderson (1983) found that education courses were positively associated with successful teaching.

Nathan and Petrosino (2003) concluded,

Educators who have advanced knowledge of a subject, but lack concomitant knowledge of how novices actually learn that subject tend toward views of student development that align more closely with the organization of the discipline than with the learning processes of student. (p. 906)

The authors indicated that their findings call into question the policies that seek to streamline the licensure process of new teachers on the basis of their subject-matter expertise.

Related to the issue of pedagogical preparation are the actual classroom behaviors of uncertified and certified teachers. Most studies examining the performance of teachers under natural teaching conditions date from the 1950s and 1960s (Ashton & Crocker, 1987). In general, these studies relied on the ratings of administrators, professors, and other instructional experts regarding the performance of fully certified and provisionally certified teachers.

Perhaps the first study of this kind, by Massey and Vineyard (1958), had 62 first-year teachers rated on a 5-point scale by their immediate supervisors. The authors found that fully certified teachers received a higher mean rating than provisional teachers, who had not met all professional program course requirements. In a similar study by LuPone (1961), administrators rated 40 fully certified and 40 provisionally certified teachers with less than 3 years of experience on their preparation, planning, subject-matter knowledge, student–teacher relations, and evaluation. Comparing teachers with the same years of experience, the administrators always rated the fully certified teachers higher than the provisionally certified teachers. Moreover, during the 2nd and 3rd years of the study, fully certified teachers were ranked higher than provisionally certified teachers in terms of their instructional expertise.

During a relatively severe teacher shortage in the late 1950s, many districts resorted to hiring teachers with emergency certification only (Ashton & Crocker, 1987). In response, three dissertations (Beery 1962; Gerlock, 1964; Gray, 1962; all as cited in Ashton & Crocker) at Florida State University compared fully certified teachers to emergency certified teachers. The study by Beery compared 76 provisionally certified first-year teachers to 76 fully certified first-year teachers. Further, each provisionally certified teacher was matched with a fully certified

teacher within the same school and with the same teaching assignment. Teachers were also matched as closely as possible with respect to their age, sex, college major, college grade-point average, and college attended. On all 45 of the measures of teaching effectiveness used in the study, the fully certified teachers scored higher than the provisionally certified teachers. The differences between the two types of teachers were statistically significantly greater on 25 of the measures.

The study by Gerlock (1964, as cited by Ashton & Crocker, 1987) focused on secondary teachers and used observations by principals using a teacher evaluation form developed by the Florida Department of Education. Relevant to this study, the results of chi-square analyses showed statistically significant differences between provisionally and fully certified teachers on teaching skills, professional ethics, and performance.

A study by Cornett (1984a) examined the classroom performance of teachers holding regular and temporary teaching certificates in Georgia. Teachers in both groups held bachelor's degrees and were matched on subject and grade level taught. Teachers were evaluated using a locally developed teacher evaluation system. The results of the study showed that the fully certified teachers had higher average scores. However, since the fully certified teachers also had greater average teaching experience, it is difficult to draw conclusions from this study. Another study by Cornett (1984b) compared the classroom performance of 191 provisionally certified teachers and 292 fully certified teachers in North Carolina. The teachers' performances were rated on 33 basic teaching functions using a 4-point scale. Again, Cornett found no differences in the mean scores of the two types of teachers. A study by Clarridge (1990) found that after controlling for experience, teachers with pedagogical training were better able to ensure students

were on task, to provide appropriate feedback to students, properly to assess student achievement, and more effectively to deliver the content.

Wenglinsky (2002) conducted the most recent and most rigorous research relating teacher behaviors and student achievement. In his study, he linked teacher behaviors in the classroom with student achievement on the NAEP. He contended that one of largest influences on student achievement is particular teacher behavior. For example, he found that students in classes in which mathematics teachers emphasize higher order thinking skills score about 40% of one grade level higher than their counterparts in classes in which teachers do not emphasize higher order thinking skills. In both mathematics and science, students in classrooms in which teachers require hands-on learning activities have greater scores in both subjects than their peers.

In their review of the literature on pedagogy and subject-matter knowledge, Ashton and Crocker (1987, p. 6) concluded, “Findings do not provide an empirical justification for increasing requirements in academic subject areas at the expense of reducing coursework in how to teach.” In other words, both subject-matter and pedagogical expertise are important factors in explaining student achievement.

Teacher Experience

Teacher experience long has been thought to affect student achievement, with more experienced teachers associated with greater gains in student achievement. Although not directly related to teacher certification, there is a connection between the two. Beginning teachers who are fully certified tend to have more classroom experience than their uncertified counterparts. This experience is gained through observation blocks and student teaching as an undergraduate. Most uncertified beginning teachers do not have these types of experiences, thus have less actual classroom experience.

In studying the effects of teachers on student achievement in elementary schools, Rowan, Correnti, and Miller (2002) found rather large effects on student achievement in both mathematics and reading. The effect sizes for 1 year ranged from .21 to .42 in mathematics and reading, while the effect sizes over 3 years ranged from .77 to .88. The largest predictor of student achievement in terms of teacher characteristics was teacher years of experience.

Ferguson (1991), in his study of over 900 school districts in Texas, found that teacher experience was positively associated with student achievement gains at the district level. Likewise, Murnane and Phillips (1981) found that teacher experience had a positive effect on student achievement for inner-city students. In their study of high school students, Ehrenberg and Brewer (1994) found that teacher experience was positively related to White and African American student gain scores, but negatively related to Hispanic gain scores. Goldhaber and Brewer (1996) also found that teacher experience is positively related to high school student achievement. Interestingly, in his study of high school mathematics and science teachers, Monk (1994) found that teacher experience had no effect on student performance.

Certification and Student Achievement

As Ashton and Crocker (1987) and Goldhaber and Brewer (2000) noted, very few studies have compared the performance of students taught by uncertified or improperly certified teachers and by properly certified teachers. Hall (1962) conducted one of the earliest of such studies. He compared student gain scores on six areas of the Stanford Achievement Test for 21 provisionally certified teachers and 17 fully certified teachers who were assigned to teach Grades 3–5. Hall found that the students taught by fully certified teachers made statistically significantly greater gains in spelling, paragraph meaning, and word meaning.

Strauss and Sawyer (1986) examined the relationship between NTE scores of North Carolina teachers and district-level student performance. They found that teachers' scores on the NTE and student performance were strongly and positively associated. A similar study by Ferguson (1991) in Texas focused on the relationship between district-level fiscal and human resources and student performance. Ferguson found that composite teacher qualifications explained more of the between-district variance in scores than did student socioeconomic status. Ferguson measured teacher quality by examining teachers' experience levels, degree levels, and scores on a state licensing examination given to all teachers in the field. The Texas Examination of Current Administrators and Teachers (TeCAT) measured teachers' basic verbal and mathematics skills as well as teaching knowledge. Of these teacher quality components, the component with the strongest relationship to student performance was teacher scores on the state licensing examination.

Hawk et al. (1985) conducted one of the best studies of the effect of teacher certification on student performance. In this study, the researchers compared the mathematics achievement of students taught by improperly and properly certified mathematics teachers. Thirty-six teachers and 826 students participated in the study, which assessed student achievement in both general mathematics and algebra. The researchers found that students taught by properly certified mathematics teachers made statistically significantly greater gains in both general mathematics and algebra.

In a very recent study that looked at the application process for The National Board for Professional Teacher Standards (NBPTS), each applicant has to complete assessments on both pedagogical and content knowledge. Goldhaber and Anthony (2004) found that elementary student achievement gains were larger for student taught by NBPTS-certified teachers than

students taught by noncertified teachers. Another recent study found that Arizona students who had teachers that were National Board Certified had greater gains in achievement (Vandevoort, Amrein-Beardsley & Berliner, 2004)

Goldhaber and Brewer (2000) found that 12th-grade students taught by teachers certified in mathematics had greater gains on a mathematics assessment than students taught by either uncertified teachers or teachers certified in nonmathematics subject areas. In other words, they found that improperly certified teachers produced lower gains in student achievement than properly certified teachers. On the other hand, the researchers found that there were no differences in the gains in student achievement on a science assessment between students taught by teachers certified in science and students taught by either uncertified or improperly certified teachers.

Results in a study by Alexander and Fuller (2004) indicated that the estimates for the 1999 Texas state achievement exam scores for students who had certified teachers compared to noncertified teachers were statistically significant. Results indicated that, on average, students who had a certified teacher had greater gains on the mathematics exam than students who had noncertified teachers, after controlling for several variables.

Darling-Hammond (2000) found that the percentage of teachers with both a subject-matter major and full state certification is positively associated with a state's reading and mathematics scores on the NAEP. She also found that a state's average NAEP scores in mathematics was negatively associated with (a) the percentage of teachers less than fully certified, (b) the percentage of beginning teachers less than fully certified, and (c) the percentage of all newly hired teachers not certified. Goldhaber and Brewer (2000) also found students taught by fully certified mathematics and science teachers had greater gains in student scores than

students taught by teachers with emergency, probationary, or no certification. The results for mathematics were stronger than for science.

A recent study by Laczko-Kerr and Berliner (2002) directly addressed the issue of the effect of teacher certification on student achievement. The researchers created matched pairs of certified and uncertified teachers. Teachers were matched based on their certification status (an uncertified teacher was matched with a certified teacher) and were matched with teachers (a) within the same school, (b) within the same district, or (c) within similar districts. This matching procedure was adopted to “minimize exogenous variables associated with student achievement scores” (Laczko-Kerr & Berliner, p. 24). Based on their analysis of the gain scores of 109 matched pairs of teachers, the authors found that students in classrooms of undercertified teachers would have made 20% more growth had they been assigned to certified teachers classrooms. Indeed, they asserted their findings support the contention that “university prepared teachers are of higher quality than those prepared without an approved program of preparation” (Laczko-Kerr & Berliner, p. 39).

While some studies suggest that certified teachers are more effective in eliciting greater gains in student achievement from their pupils, the research is far from conclusive. First, the studies are contradictory in their results, and second, a very small number of studies have been published.

Summary of Research

While the research in teacher preparation is certainly not large or consistent, the evidence suggests that both subject-matter knowledge and pedagogical knowledge are positively related to student achievement. Indeed, as Monk (1994, p. 142) stated, “It would appear that a good grasp of one’s subject area is a necessary but not a sufficient condition for effective teaching.”

Similarly, pedagogical preparation and/or certification appear to be positively associated with teaching behaviors that are thought to be effective. In addition, the majority of studies suggest that teacher experience is positively associated with student achievement. Finally, a small handful of studies have found that students taught by certified teachers have greater levels and gains in achievement than their peers taught by uncertified teachers. However, the number of such studies is quite small and tends to focus on mathematics, science, and reading to the exclusion of other subject areas.

The goal of this study was to look at patterns of teacher qualifications in association with student performance. By understanding more about which teacher qualifications are most strongly related to student performance, researchers can inform educators and policymakers about the most effective ways to increase the capacity of schools and districts.

Methodology

Data Sources

This study relied on four different original sets of data.

1. The first set of data was obtained from three different school districts in Texas. Each data set linked individual students with individual teachers for the 1997–1998 and 1998–1999 academic years.

2. The data set from the Texas State Board for Educator Certification (SBEC) includes the demographics of teachers (race/ethnicity, age, and gender), years of experience, and areas of certification.

3. The data set from the Texas Education Agency includes individual student data such as demographics (race/ethnicity, economic status, grade level), program participation (ESL, bilingual, special education), and test scores on the Texas Assessment of Academic Skills

(TAAS), a criterion-referenced test mandated by the state to be taken by all students in Grades 3–10 and Grade 10.

4. Another data set obtained from the Texas Education Agency includes school- and district-level information on student demographics and total enrollment.

This study focused on teachers holding a state teaching certificate who are teaching in their subject area of teaching. In this study the student performance measures are TAAS scores for the 1998 and 1999 administration in mathematics. The district data identified teachers from whom students received instruction for one year in mathematics. The final sample analysis had 11,778 seventh- and eighth-grade students from three large Texas school districts. Characteristics of the teachers and students were taken into account in this analysis including the years of teaching experience. Adjustments (controls) were added for student demographics and program assignments such as gifted/talented, special education, and limited English proficiency (LEP). The data used were district classroom assignment, Public Education Information Management System (PEIMS) assignment data, revised PEIMS experience data, certification data, and individual student TAAS data.

The Texas Learning Index (TLI), which is derived from raw scores, was used as the measure of TAAS results. The TLI is an index of student achievement toward the goal of passing the exit-level TAAS test in 10th grade. It allows for comparisons between administrations and between grades. The TLI is anchored at the exit-level passing standard (a scale score of 1,500) which was established to be 70 with a standard deviation of 15. This established level of passing performance, TLI of 70, is relative to the mean performance of the other students at a particular grade. The TLI defines typical progress as maintaining the same position relative to one's peers from grade to grade. The anchor, TLI of 70, is the passing score at all grades. The Texas

Education Agency (2001) *Student Assessment Program Technical Digest 2001-2002* indicated the TLI ranges from approximately 0 to 100. The minimum expectation score of 70 represented the same amount of achievement at each grade tested and at each administration. This enabled the use of the TLI to assess achievement, as tested by the TAAS, across grades. Because the TLI could be compared across grade levels, it could be used as a type of pretest/posttest to determine maintenance, loss, or growth in achievement. It should also be noted that any actual gain in TLI could be considered gain in one grade-level of achievement *plus* additional achievement.

Additionally, because the TAAS is a criterion-referenced test, there can be a rather large ceiling effect as well as a large majority of students obtaining a TLI of 70 or above (the goal of the Texas education system). Because of these test score limitations, control variables were added to control for the basement, ceiling, and mode effect to adjust the resulting cubic curve.

Description of Methodology

In this analysis, a value-added model was constructed by using each student's previous-year TLI score as a proxy for each student's academic level. A previous score has been used as a proxy for previous learning in multiple regression analysis by many educational researchers (Rumberger & Willms, 1992; Sanders & Rivers, 1996). This allows for the value-added analysis from a baseline year (represented by the previous score) to the following year.

The statistical technique of multiple regression was used to analyze the data. Important indicator variables were used as well as variables that were used only for the ability to control or account for certain characteristics of the model (such as cubic curve). The final regression model was decided upon by investigating many models with different combinations of independent variables. For this analysis, the most important variable to examine was the infield teaching

variable describing whether a certified teacher was teaching in the area in which they are certified.

A standard multiple regression analysis employed TAAS scores for 1999 as the dependent variable. Independent variables were TAAS scores for 1998, student ethnicity, economically disadvantaged status, at-risk status, student program indicator (e.g., special education, LEP, gifted/talented), percent nonminority students, campus percent economically disadvantaged, campus percent LEP, campus student-teacher ratio, and whether the campus is considered urban or suburban. All the campuses in the sample were either suburban or urban as labeled by National Center for Education Statistics common core of data (CCD). Additional independent variables were district percent economically disadvantaged, controls for high and low TAAS scores (due to ceiling and range effect), teacher years of experience, whether a teacher held a master's degree or above, and whether a certified teacher was teaching in or out of certification area. The certified teachers had a valid Texas teaching certificate, and included teachers who went through a traditional and/or alternative educator preparation program.

Analyses assessed the validity of the regression assumptions in the final model. The Durban-Watson statistic was used to measure the correlation among the errors to test the independence assumption. The examinations of residual plots and curve estimations led to some adjustments to meet regression assumptions. A cubic adjustment of the dependent variable assisted in improving the model to meet the linearity and equal variance assumptions. Because interpreting coefficients in light of a cubic metric can be confusing, we decided to address the cubic curve estimate through the use of TAAS score adjustments for high and low scores. Given that the TAAS is a criterion-referenced test that has been administered for several years, there tends to be a ceiling effect as well as a basement effect (students not exempt, but not responding

any or very little). Finally a formal test of the assumption of equal variance was made that indicated that the final model output did not present a statistically significant departure from equal variance.

Findings

The means were compared using an unpaired t test to determine if the difference in mean gains between the two groups (students of in-field or out-of-field teachers) was significant. The output of the t test is a p value; p values of less than 0.05 are considered significant, which means there is less than 5% probability that the means were two different measurements of the same value. The average scores for the achievement performance of the in-field taught students and the out-of-field taught students were significantly greater at $p \leq 0.05$.

The regression results indicated that a gain in student achievement scores was significant for the students of in-field teachers ($p = 0.042$); however, an effect size of 0.40 was calculated for the null hypothesis, indicating that this gain was not a large effect (using a pooled estimate of standard deviation). Effect size is a statistic that measures the size of the effect of an intervention by controlling for variations in standard deviation; it is independent of scale. The effect size characterizes the degree to which sample results diverge from the null hypothesis. The null hypothesis in this case was that students of in-field teachers score the same on the mathematics TAAS exam than students of out-of-field teachers.

Linear model assumptions were investigated. A Durban Watson statistic, which measures the correlation among the errors when the cases are equally spaced in time, indicated a value of 1.965. The statistic was in the acceptable range (unacceptable range is a value less than about 1.4 or greater than about 2.6), indicating no violation of the independence assumption. Also, a formal test of equal variance was performed. Violations of the equal variance assumption can

often be seen in a plot of the studentized residuals versus the predicted values. The results of equal variance test performed on this data set indicated there was not a statistically significant departure from equal variance

The major findings indicate that compared to seventh- and eighth-grade students with teachers teaching out of certification area, the students with teachers teaching in their area of certification, on average, performed better on the 1999 TAAS math assessment. These results included controlling for other important variables such as student characteristics, teacher characteristics, and the campus and district characteristics (see Table 1).

As mentioned earlier, the TLI score defines typical progress as maintaining the same position relative to one's peers from grade to grade. As a result, this model indicated that on average a student who had a certified teacher gained a grade level plus about a half of a TLI unit point. This was significant but did not seem substantial, particularly when factoring in the effect size of 0.40. However, results indicated that something is increasing students' achievement scores when they have a certified teacher teaching in their area of certification.

Student characteristics included in the model helped hold constant individual differences that affect the students' scores. In general minority status, participation in free and reduced-price lunch program, participation in special education, and being at-risk of dropping out means that students in those groups tended to receive lower test scores than students not in those specific groups. Overall, this means that these students, compared to their counterparts, tended to have lower TAAS mathematics exam scores. Students that participated in the gifted and talented program tended to have significantly higher scores, averaging over 1.50 TLI units higher.

The campus and district variables were included to account for the students' environment, their particular campus and district. The district student-teacher ratio estimate was

significant, indicating that when the student–teacher ratio increased (more students in a classroom), the math achievement score on average decreased significantly (about 150 TLI unit points). As a result, this variable seemed to be a strong predictor of student achievement.

The goal of this study was to look at patterns of teacher qualifications in association with student performance. This study addressed the question of whether teachers’ teaching in their content area of certification affects the math achievement scores of their students. The results indicated that students who receive instruction from teachers who teach in their area of certification tend to fare better on average in math achievement scores than students taught by teachers teaching outside their area of certification.

Conclusion

The analysis indicates that the estimates for the 1999 TLI scores for students who had certified teachers teaching in their area of certification compared to student scores of certified teachers teaching out of their area of certification were statistically significant. This indicates that, on average, students who had a teacher teaching infield had greater gains on the TAAS mathematics exam than students having teachers teaching out-of-field, after controlling for several variables.

The findings of this study indicate that certified teachers teaching in their area of expertise are associated with increased student achievement on the state-mandated TAAS mathematics test. Moreover, this conclusion holds after controlling for a host of other factors, including student demographics, school and district demographics, teacher years of experience, percent of teachers with a master’s degree at a campus, and prior student achievement.

By understanding how teacher qualifications are most strongly related to student performance, researchers can inform educators and policymakers about the most effective ways

to increase the capacity of schools and districts to improve student achievement. This is an important area of focus for researchers, education administrators, and policymakers. Teacher qualifications and teacher placement are important issues to the learning that goes on in the classroom. Policymakers can use information from this study and other studies to look at education funding, teacher preparation, and teacher certification issues.

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Table 1

Regression Results

Variables ^a	Unstandardized		Standardized		<i>t</i>	Sig.
	coefficients		coefficients			
	<i>B</i>	Std. error	Beta			
Student variables						
1998 math TLI	0.263	0.006	0.264	47.529	0.000	
Hispanic	-0.530	0.161	-0.020	-3.302	0.001	
African American	-0.795	0.171	-0.022	-4.626	0.000	
Asian	0.080	0.211	0.001	0.377	0.706	
Native American	-2.857	1.059	-0.008	-2.698	0.007	
Econ. disadv.	-0.319	0.119	-0.012	-2.681	0.007	
Special education	-1.186	0.181	-0.021	-6.572	0.000	
Gifted/talented	1.579	0.124	0.045	12.733	0.000	
LEP	-0.063	0.166	-0.001	-0.378	0.705	
At risk of dropping out	-1.423	0.112	-0.054	-12.740	0.000	
Teacher variables						
Teaching in area of certification	0.448	0.220	0.007	2.039	0.042	
Teaching experience	-0.007	0.004	-0.005	-1.616	0.106	
Campus % master's or above	-0.927	0.563	-0.008	-1.645	0.100	

Variables ^a	Unstandardized		Standardized	<i>t</i>	Sig.
	coefficients		coefficients		
	<i>B</i>	Std. error	Beta		
Campus variables					
Campus 99% econ. disadv.	-0.030	0.007	-0.076	-4.224	0.000
Campus 99% LEP	0.001	0.010	0.001	0.088	0.930
Campus 99% nonminority	-0.012	0.007	-0.020	-1.767	0.077
Campus student-teacher ratio	-0.018	0.038	-0.002	-0.460	0.645
Campus is suburban (CCD)	-0.225	0.232	-0.005	-0.794	0.336
District variable					
District student-teacher ratio	-1.497	0.373	-0.048	-4.012	0.000

^aAdditional high/low score adjustments were made to maintain linearity.

Note. $R^2 = .893$, Durbin-Watson = 1.965, CCD = Common core of data, National Center for Education Statistics.