Article

Educational Policy
2015, Vol. 29(4) 645–675

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DOI: 10.1177/0895904813510777
epx.sagepub.com
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Teacher Effectiveness: An Analysis of Licensure Screens

James V. Shuls[1] and Julie R. Trivitt[2]

Abstract
Historically, the government has sought to improve the quality of the teacher workforce by requiring certification. Teachers are among the most licensed public personnel employees in the United States. Traditionally, an education degree with a student teaching experience and passage of licensure exams were necessary for licensure. In the 1980s, alternative paths to certification developed. In this article, we evaluated the impact of licensure screens and licensure routes on student achievement. Our findings from an analysis of Arkansas data suggest that there is little difference in terms of quality between traditionally and alternatively certified teachers. However, licensure exams do have some predictive power.

Keywords
education, teacher quality, value-added, certification, education policy

In a 2009 town hall meeting, President Barack Obama commented, the “single most important factor in the classroom is the quality of the person standing at the front of the classroom.” Intuition and empirical research affirms this claim, as a broad research base has documented the impact teacher quality has on student achievement (Hanushek, Kain, O’Brien, & Rivkin, 2005; Rivkin, Hanushek, & Kain, 2005). Ensuring teacher quality has traditionally

[1]Show-Me Institute, St Louis, MO, USA
[2]University of Arkansas, Fayetteville, USA

Corresponding Author:
James V. Shuls, Show-Me Institute, 4512 W Pine Blvd., St Louis, MO 63108, USA.
Email: james.shuls@showmeinstitute.org

been achieved through a certification requirement. Indeed, every state regulates who can enter the teacher labor force through some form of teacher certification (Walsh, 2001). Ideally, certification weeds out individuals who would be of low quality and allows individuals who would be satisfactory teachers to enter. The standard teaching certification typically can only be earned by individuals with a degree in education. Recently, however, there has been a growing movement to expand alternative pathways to the classroom for individuals with other academic degrees. In Arkansas, like many other states, alternatively certified teachers must pass the same licensure exams as traditionally certified teachers. The emergence of alternative routes and the reliance on tests to screen out individuals lead to an important policy question: Are current teacher licensure screens adequate indicators of teacher quality?

Throughout history, governments have sought to regulate various occupations by enacting laws that limit entry into the profession. A common method of regulating a profession is to require occupational licensing of individuals who wish to carry out the trade. Kleiner (2000) defined occupational licensing "as a process where entry into an occupation requires the permission of the government, and the state requires some demonstration of a minimum degree of competency" (p. 191). This type of occupational licensing has existed in America since colonial times, but the prevalence of licensing exploded in the later part of the 1800s (Rottenberg, 1962). Today, roughly 29% of the entire U.S. workforce is comprised of workers required to have a license, with the largest groups of licensed workers being teachers and nurses (Kleiner & Krueger, 2010).

A distinction is typically made between occupational licensing and certification. Kleiner (2000) suggested that both licensing and certification require the demonstration of basic skills, but consumers can choose whether to hire a certified person, whereas it is illegal for someone without an appropriate license to perform the regulated job. In education, the two terms are often used synonymously. Although it is possible to hire an uncertified teacher, it is typically discouraged if any certified applicant is available.

The rationale for licensing is often based on consumer protection. Policymakers want to keep charlatans out of the profession and ensure a minimum quality of goods or services for consumers. In theory, ensuring minimal quality helps the consumer by protecting them from potential hazards and by improving the average quality of goods or services received. Although consumer protection and improving quality are often cited as the primary reasons for licensing, it must be noted that the practitioners of the regulated trade also benefit from increased regulation. Friedman and Kuznets (1945) demonstrated how increased licensing acts as a barrier to entry and allows regulated professionals to charge higher fees for their services. An increase in wages occurs because the supply of workers in the regulated field is decreased. Limiting the supply of providers decreases the supply of available labor, thus increasing the price, or wage paid, for the professional already practicing the profession (Kleiner, 2000; Kleiner & Krueger, 2010; Rottenberg, 1962). Indeed, evidence suggests that occupational licensing increases wages by approximately 15%, roughly the same impact as unionization (Kleiner & Krueger, 2010).

Adam Smith (2010) also identified this phenomenon of increasing prices through regulation in 1776. At that time, it was common in many townships to require tradesmen to undertake a lengthy apprenticeship before practicing a trade independently. The lengthy apprenticeship discouraged some from entering these professions. What's more, many of these professions limited the number of apprentices a master could have. As Smith (1776) stated, "the intention of both regulations is to restrain the competition to a much smaller number than might otherwise be disposed to enter the trade" (chap. X, Pt. II). These rules were ultimately codified into laws in many places, with the practitioners of the trade actively lobbying for passage of the very regulations that benefit their business.

Though formal apprenticeships are no longer the norm, occupational licensing still limits access to professions in a number of ways. A common requirement for many occupational licenses is passing some sort of entrance exam; in Arkansas, teachers must pass a Praxis exam of professional knowledge and at least one on the content of the grade or subject they wish to teach. In addition, many licenses require individuals to obtain specific education credentials (Kleiner, 2000). To be a traditionally certified teacher in Arkansas, one must earn a degree in education, while the alternative license can be awarded to an individual with any bachelor's degree. Residency requirements, such as student teaching, are also needed to obtain licenses in many fields. Each of these, examinations, education, and residency requirements, increases the costs of entering a profession (Rottenberg, 1962). Individuals incur the cost of tuition and exam fees in addition to giving up time and money that could be earned while meeting the licensing requirements.

That these barriers increase a teacher's potential wages seems an innocuous side effect, if indeed they improve the overall quality of those in the profession. Yet licensing does not just increase wages and keep the incompetent from entering the profession; it may also keep out highly effective individuals by placing barriers to entry (Podgursky, 2004). The transaction costs may prevent competent individuals from ever considering a career in teaching. In addition, poor screens for licensure may keep potentially effective individuals from entering the profession and allow entrance for ineffective teachers. Goldhaber (2007) illustrated the importance of licensure screens that are highly correlated with the desired outcome, teacher effectiveness. When a licensure screen is weakly correlated with the outcome of interest, the screen misidentifies teachers. A perfect screen would keep out low performers and only allow in high performers. A poor licensure screen allows some low-quality individuals to gain a license while keeping out some potentially effective teachers. The weaker the correlation between the licensure screen and teacher quality, the more likely we are to issue certification to individuals who should not teach and deny certification to individuals that would be effective teachers.

It is impossible to perfectly detect the impact licensing has on the quality of individuals in the teacher labor force because we cannot observe the individuals who do not enter teaching. This includes the grossly inadequate teacher who cannot pass the licensure screens and the highly capable individual for whom licensing screens act as a barrier to free entry into the profession. Yet, we can ascertain some indication as to whether our current licensing practices are adequate at identifying quality individuals in two ways. The expansion of alternative pathways to licensure allows us to compare traditionally certified teachers with alternatively certified teachers. Though alternative certification imposes many of the same requirements on potential teachers, it provides an interesting counterfactual to traditional certification. We can also evaluate the licensing process through the use of licensing exams. The analysis of the impact of licensure route and licensure exams on student achievement comprises the two key research questions for this article.

Research Questions

Research Question 1: Do traditionally certified and alternatively certified teachers generate the same increase in student achievement on standardized exams in math and language arts?

Research Question 2: Does a teacher's score on licensure exams influence student achievement?

Our Contribution

Although there have been a number of studies on the impact of licensure route and test scores on student achievement, these studies have been conducted in few states and the results are not yet conclusive, especially in regard to certification. Furthermore, most rigorous studies have been conducted in locations where the labor force has a higher educational achievement on average that is available in rural states, such as Arkansas. We expand on the body of knowledge by providing analyses in an environment that is much different than New York City or North Carolina. Very few prospective Arkansas teachers attended a highly competitive university. No Arkansas college or university is listed in the highest competitive rating category by *Barron's Guide to the Most Competitive Colleges*. Arkansas's flagship, land grant institution, the University of Arkansas, is listed as number 132 on *U.S. News & World Report's* National University Rankings (2011). No other Arkansas institution of higher learning is listed on the national university rankings. Arkansas also has a smaller percentage of the adult population with college degrees, 18.9% compared with 31.8% and 25.8% in New York and North Carolina, respectively (U.S. Census). Thus, Arkansas has a smaller pool of individuals for which alternative teacher certification is even viable. In short, the findings from Arkansas may generalize to parts of the United States, particularly rural states, in a way that New York and North Carolina cannot.

Literature Review

As noted above, it is impossible to accurately determine the impact licensing has on the overall quality of the teacher workforce because we do not know who is truly being kept from the classroom. Yet we can estimate the effects by examining the difference between traditionally and alternatively certified teachers and the link between licensure exams and teacher quality. In recent years, there has been a growing literature on the impact of observable teacher characteristics on student achievement. This trend has been quickened by the growth of longitudinal data sets linking teacher credentials to student achievement. New York and North Carolina have been at the forefront of developing these rich data sets. Accordingly, a majority of studies that have rigorously examined teacher quality in terms of increasing student achievement have been conducted in these states. In this section, we report the findings on teacher certification and licensure exam scores from these states, and others.

Certification

Traditionally, teachers have been required to earn a degree in education and student teaching experience before becoming a teacher of record. In the 1980s, alternative routes to the classroom emerged. Mid-career switchers are often attracted to alternative programs because they make it easier to enter the classroom (Johnson, Birkeland, & Peske, 2005). Though the requirements vary, every state requires some form of certification for teachers. In most states, there are a multitude of certifications offered to prospective teachers. Teachers can earn these certifications via a traditional or an alternative route, but typically have to pass several exams.

The standard (traditional) method for gaining certification is to earn a bachelor's degree in education with a student teaching component. Any other path is considered an alternative route to the classroom. Alternative pathways range in quality and include teachers who enter with emergency certifications or enter through a highly competitive program, such as Teach for America (TFA). Alternative certification comes in many varieties, but a typical alternative certification route requires individuals to have a bachelor's degree or relevant experience in the field they wish to teach. These individuals typically must pass the relevant licensure exams and in some cases are required to take specific education coursework prior to or during their first year in the classroom.

The evidence is mixed in terms of traditional and alternative pathways to the classroom.

When all nontraditional teachers are lumped together, the results tend to favor traditionally certified teachers. Boyd, Lankford, Loeb, Rockoff, and Wyckoff (2008) noted that noncertified teachers in New York City were significantly worse than traditionally licensed teachers. Similarly, Clotfelter, Ladd, and Vigdor (2010) have found alternatively certified teachers in North Carolina to be significantly worse than traditionally licensed teachers in high school and in third through fifth grade (Clotfelter, Ladd, & Vigdor, 2007). Goldhaber and Anthony (2007) found similar results.

Others have found no significant difference between traditionally and alternatively certified teachers. For instance, Croninger, Rice, Rathbun, and Nishio (2003) found no difference in terms of effectiveness for 1st-grade teachers from various routes. Similarly, Goldhaber and Brewer (2000) reported insignificant differences for 12th-grade math and science teachers. The only random assignment study of alternative certification found no significant difference between traditionally and alternatively certified teachers (Constantine et al., 2009).

One problem with the aforementioned studies is how they lump all forms of alternative certification together. As we have noted, alternative licenses can be obtained through a variety of programs with varying levels of difficulty for entrance. When specific programs, which tend to be more selective than colleges of education, are examined, the results are a bit more positive for alternative certification. The most highly touted program, TFA, was analyzed via a random assignment experiment by Glazerman, Mayer, and Decker (2006). In this analysis, TFA teachers were compared with other teachers within their school regardless of their certification route. Thus, TFA was compared with the status quo, rather than TFA being compared with only traditionally certified teachers. This is an important distinction, because the schools TFA serves tend to have difficulty hiring only traditionally certified teachers. The results were positive and significant in math, but TFA teachers were no different in terms of performance in reading.

TFA has also been analyzed numerous times in nonexperimental studies, whereby TFA is compared with only traditionally certified teachers. These studies also find a mixture of positive and null results between TFA teachers and traditionally certified teachers. Analyzing data from novice New York City teachers of fourth- through eighth-grade students, Rockoff, Jacob, Kane, and Staiger (2008) found TFA teachers to be more effective; however, the difference was not statistically significant. Similarly, Boyd, Grossman, Lankford, Loeb, and Wyckoff (2006) and Boyd et al. (2008) did not find significant differences between TFA and traditionally certified teachers in their examination of New York City data for teachers of fourth through eighth grade. Kane, Rockoff, and Staiger (2008) found TFA teachers to be more effective in math instruction, but not so in reading.

Xu, Hannaway, and Taylor (2011) were the first to estimate the impact of TFA teachers on high school student achievement. Using North Carolina data, they found that TFA teachers improved student achievement significantly more than non-TFA teachers in math, science, and English language arts (ELA). These findings held even when they compared TFA teachers with more experienced teachers who were teaching within their own field. Taken as a whole, TFA teachers seem to be as effective, if not slightly more effective, in raising student achievement as their traditionally certified counterparts.

The New York City Teaching Fellows (NYCTF) is another selective alternative certification program that has been evaluated numerous times. Like TFA, results for the NYCTF have been mixed, but they tend to be slightly less positive. Rockoff et al. (2008) found NYCTF to be marginally less effective than traditionally certified teachers, but the differences were not significant. Boyd et al. (2008) found positive, but insignificant results for NYCTF. And Kane et al. (2008) found no significant difference between NYCTF and traditionally certified teachers in math, while the fellows performed slightly worse in reading. As usual, the differences tended to be small.

Another notable alternative certification program is the American Board Certification of Teacher Excellence (ABCTE). Like TFA, ABCTE teachers are certified in a number of different states. Unlike TFA, evaluations of ABCTE have been conducted in only one of the states in which teachers are currently offered initial certification, Florida. As expected, the results are mixed. Using a matching approach with 30 ABCTE teachers of 4th- through

10th-grade students in Florida, Clark Tuttle, Anderson, and Glazerman (2009) found ABCTE teachers to be no different from their matched comparison of traditionally certified teachers in reading, but ABCTE teachers were significantly worse in math. These findings are in contrast to the fixed-effects analyses of Sass (2011), who found ABCTE teachers to be significantly more effective in both math and reading.

Though alternative pathways are not unequivocally better or worse than traditional pathways, there are some clear distinctions between the two routes to the classroom. Alternatively certified teachers are more likely to be from highly competitive universities (Boyd et al., 2006; Glazerman et al., 2006; Kane et al., 2008; Sass, 2011). They are also more likely to score higher on the SAT (Sass, 2011) or licensure exams (Boyd et al., 2006; Boyd et al., 2008). Indeed, Boyd et al. (2008) noted,

> Only 5% of newly hired Teaching Fellows and TFA teachers in 2003 failed the Liberal Arts and Sciences Test (LAST) exam on their first attempt, while16.2 percent of newly hired traditional teachers failed the LAST exam, and fully 32.5% of uncertified teachers failed the LAST exam. (p. 815)

Alternatively, certified teachers also tend to be more male than traditionally certified teachers (Sass, 2011). As a result, alternative certification may have the ability to change the composition of the workforce by bringing high-performing individuals and males into the profession.

During the 1999-2000 school year, approximately 60% of all newly hired New York City teachers were uncertified (Kane et al., 2008). Alternative routes, like NYCTF and TFA, were created to certify teachers to fill the void of certified teachers. The programs have had remarkable success at increasing the number of certified teachers. By 2004-2005, the percentage of uncertified new hires had dropped to only 7%. At the same time, the number of alternatively certified teachers increased from 2% to 36%. Kane et al. (2008) noted that the shift from uncertified to alternatively certified teachers was not simply a sleight of hand where uncertified teachers were awarded an alternative certificate. The alternative licensure programs attract different individuals, as measured by observable characteristics. As noted above, teachers in alternative programs tend to be higher performing and have attended more selective universities. This is one of the promises of alternative licensure programs, to attract high-performing individuals from other professions.

The results are mixed, but they seem to suggest that there are not large, systematic differences in quality between traditionally and alternatively certified teachers as a whole. However, it is important to note that much of the literature on teacher certification comes from only a few locations, primarily

New York and North Carolina. The findings in these states may not generalize to other parts of the country, as these states have a relatively large number of highly competitive universities and capable entrants into alternative certification programs. It may be the case that alternative certification programs in these areas are able to recruit higher quality applicants than alternative certification programs in places like Arkansas, due to fewer college graduates in the labor force and fewer highly selective universities.

Licensure Exams

Policymakers typically want to ensure that teachers have an appropriate level of content knowledge in the subject they wish to teach. Accordingly, tests of basic skills and content knowledge have been required in most states. In addition, teachers are often required to have a minimum level of pedagogical knowledge. Arkansas is one of many states to use the Praxis test series developed by Educational Testing Service (ETS) to assess basic knowledge, content knowledge, and pedagogical knowledge. In fact, the Praxis series is the most widely adopted series of tests used for teacher licensure. Thus, teachers in Arkansas and many other states are required to pass at least three exams: basic skills, pedagogy, and content knowledge.

States use each of these tests on a pass/fail basis. Cut scores, even on the widely used Praxis tests, are determined by policymakers in each state. Consequently, teachers display appropriate levels of knowledge by exceeding the minimum cut score. The logic behind the usage of cut scores implies that an individual who fails the exam by one question is not fit to teach, while the individual who earns a score equal to the cut score is deserving of a teaching certificate. The evidence, however, contradicts this assumption. Using North Carolina data, Goldhaber (2007) examined the impact adjusting cut scores would have on the overall quality of teachers. He concluded that North Carolina would eliminate more effective teachers than very ineffective teachers if the state were to adopt Connecticut's higher cut score. He similarly found no improvement in teacher quality when North Carolina increased their cut scores. In Texas, Hanushek et al. (2005) found no statistical difference between teachers who passed the licensure exam and those who did not.

By using teacher licensure exams, states are able to weed out lower performing individuals, in terms of test performance, but this provides little information to future employers on the ability of prospective teachers. The exam scores may offer more information as a continuous score. There is mounting evidence that licensure exams as a continuous score are somewhat predictive of future performance. In fact, of all the observable teacher characteristics, teacher licensure exams are among the most oft cited as having a positive relationship with teacher effectiveness. There are two reasons we might think that individuals who score higher on licensure exams would make better teachers. First, we expect individuals with a better grasp of their content to be better at instructing students on that topic. At the same time, licensure exams capture not only content knowledge but also intelligence to some extent, and we expect smarter people to be better teachers. There is some evidence to support this claim as both SAT (Boyd et al., 2008) and ACT (Ferguson & Ladd, 1996) scores have been found to be positively correlated with teacher effectiveness.

Numerous researchers have found a significant, positive relationship between performance on a teacher licensure exam and a teacher's ability to improve student achievement at the elementary (Clotfelter, Ladd, & Vigdor, 2006; Clotfelter et al., 2007; Goldhaber, 2007) and high school levels (Clotfelter et al., 2010). Clotfelter et al. (2007) noted, "Relative to the estimated effects of class size, the effects of teacher credentials appear to be quite large" (p. 30).

A common method for estimating the relationship between teacher test scores and student achievement is to standardize all teacher licensure exams. This allows researchers to utilize more data and make comparisons among teachers who have taken a variety of different tests. This provides useful information, but does not provide detailed information on the relationship between specific subject tests and how well teachers perform teaching those subjects. Clotfelter et al. (2010) separated various licensure tests in an effort to explore each subject a bit more closely. They found that subject-specific test scores in math are significantly, positively correlated with teacher effectiveness. The findings are positive and significant in biology but are smaller in magnitude when compared with math. Interestingly, English teacher licensure exams displayed a significant negative relationship with student achievement in English. Clearly, more work needs to be done to examine these relationships more thoroughly.

Data and Research Design

To examine the differences between traditionally and alternatively certified teachers and the relationship of licensure test scores with student achievement, we utilized a variety of administrative data on Arkansas public school teachers and students provided by the Arkansas Department of Education (ADE). These data include achievement and demographic student data from 2004 to 2008 on all Arkansas students in public schools from third through eighth grade (see Table 1). The data set contains student test scores on the

Table 1. Demographics for Arkansas Students in Grades 3 to 8, From 2005-2006 to 2007-2008.

Student demographic	2005-2006	2006-2007	2007-2008	Total
Total students (Grades 3-8)	205,669	207,430	209,844	622,943
Free or reduced price lunch	54.8%	55.6%	56.0%	55.5%
English language learner	2.8%	5.3%	5.5%	4.5%
Individualized education program	11.4	11.2%	10.8%	11.1%
Female	49.1%	49.1%	49.1%	49.1%
White	69.3%	67.6%	67.4%	68.1%
Black	23.0%	22.2%	22.1%	22.4%
Hispanic	5.5%	7.8%	8.2%	7.1%

state's benchmark exams in English and mathematics from 2004-2005 through 2007-2008. We are the first to link these data to teacher credentials. The teacher data include information on teacher experience, demographic information, licensure route, and Praxis I and II tests scores.

The classroom teachers from 2004 to 2008 have from 0 to 42 years of experience, so the entry into the education profession occurred from 1966 to 2007. Many of the more experienced teachers took their exams in the early 1980s as teacher testing was implemented in Arkansas. Around 2000, Arkansas switched to the Praxis series of tests. To allow us to compare test scores of teachers taking exams in different testing regimes and formats, we standardize all test scores using the cohort of all teachers in our database for whom we have a score for that test code within an appropriate score range.[1] Because we normalize over a range of years, we are implicitly assuming that the distribution of scores on a particular test does not change over time, and we are assuming that the distribution of teacher ability, as measured by test scores, is constant over time.

Tables 2 and 3 provide descriptive information about the teachers in our samples. For the information in these tables, we use all teachers in our least restrictive math model, which includes a teacher's years of experience and performance on the Praxis II. The standardized *z* scores for our tests do not equal zero because this is a subsample of our entire population of test takers. Table 2 provides information about the entire workforce for each year we analyze. Table 3 displays the differences between traditionally and alternatively certified teachers in our data. We test the significance of these differences in every domain, except grade level. We note that alternatively certified teachers tend to score higher on all licensure exams, are more likely to be male, less likely to have a graduate degree, and are more novice than traditionally certified teachers in our sample.

Table 2. Teacher Demographics by Year From the Least Restrictive Math Model.

Teacher characteristic	2005-2006	2006-2007	2007-2008
No. of Grade 5 teachers	825	1,130	1,728
No. of Grade 6 teachers	1,150	1,322	1,675
No. of Grade 7 teachers	1,193	1,443	1,815
No. of Grade 8 teachers	1,428	1,497	1,790
Teachers with a graduate degree	39.6%	38.2%	37.7%
Average Praxis I–Math z score	−.0134 (.9894)	−.0172 (.9630)	−.0376 (.9607)
Average Praxis I–Writing z score	−.0263 (.8591)	−.0066 (.8451)	−.0001 (.8322)
Average Praxis I–Reading z score	−.0079 (.8735)	−.0335 (.8544)	−.0642 (.8514)
Average Praxis II–Professional Knowledge z score	−.0384 (.8176)	−.0182 (.8081)	−.0163 (.8079)
White	87.8%	88.1%	88.4%
Black	11.3%	10.9%	10.7%
Female	79.1%	80.7%	81.6%
Years of experience	12.3 (9.6)	12.4 (9.7)	12.2 (9.9)
Nontraditional	4.1%	4.9%	6.3%

Note: Values within parentheses are standard deviations.

Following McGee and Costrell (2010), we model value-added student achievement with the following parsimonious models:

$$Y_{\text{math},t} = \beta_1 Y_{\text{math},t-1} + \beta_2 Y_{\text{math},t-2} + \beta_3 Y_{\text{ELA},t-1} + \beta_4 Y_{\text{ELA},t-2} + \rho + \gamma_{\text{math},j} + \varepsilon. \tag{1}$$

$$Y_{\text{ELA},t} = \beta_1 Y_{\text{ELA},t-1} + \beta_2 Y_{\text{ELA},t-2} + \beta_3 Y_{\text{math},t-1} + \beta_4 Y_{\text{math},t-2} + \rho + \gamma_{\text{ELA},j} + \varepsilon. \tag{2}$$

We shorten the notation a bit: $Y_{\text{math},t}$ is the achievement of student i with teacher j in school k at time t in mathematics or ELA. $Y_{i,t-1}$ and $Y_{i,t-2}$ represents student i's prior test scores, in class j, within school k, at time t; γ represents the value-added of the school-by-grade j; and ρ and ε are unobserved impacts of schools and a random error term, respectively. We do not include a student fixed effect in our model. Rather, we include 2 years of prior achievement in both math and ELA in the model to capture student time invariant characteristics, a method noted by Ballou, Sanders, and Wright (2004). Arkansas's standards and student exams are vertically aligned; nevertheless, we standardize student test scores with a mean of zero. We are unable to match students directly to teachers, so we use a random effects estimator for the school-grade level. This provides us with quality estimates at the school-grade level that are normally distributed with a mean of zero. Ideally, we would aggregate by teacher, but the data available do not match students

Table 3. Teacher Demographics by Licensure Route From the Least Restrictive Math Model.

Teacher characteristic	Nontraditional	Traditional
No. of Grade 5 teachers	94	3,789
No. of Grade 6 teachers	136	4,011
No. of Grade 7 teachers	319	4,132
No. of Grade 8 teachers	349	4,366
Teachers with a graduate degree	26.3%***	39.0%
Average Praxis I–Math z score	.4778 (.8442)***	−.0621 (.9667)
Average Praxis I–Writing z score	.2630 (.8081)***	−.0493 (.8406)
Average Praxis I–Reading z score	.3765 (.6511)***	−.0097 (.8738)
Average Praxis II–Professional Knowledge z score	.1587 (.7673)***	−.0327 (.8117)
White	88.1%	88.2%
Black	9.7%	11.0%
Female	66.0%***	81.5%
Years of experience	1.8 (2.1)***	12.9 (9.7)

Note: Values within parentheses are standard deviations.
***$p < .01$.

to specific teachers. This, however, does overcome the problem of nonrandom assignment of students to teachers. The error terms in Equations 1 and 2 capture school, teacher, and random error components combined and represent the value-added measurement, that is, academic achievement above and beyond what would be expected for the student based on past achievement.

Once the mean value-added for the school-grade is calculated, we use them to estimate the following equation:

$$u_{j,k,t} = \alpha + \psi_1 \mathbf{TQ} + \psi_2 \mathbf{TC} + \psi_3 \text{Year} + e_{jk}. \quad (3)$$

The dependent variable, $u_{j,k,t}$, is the residual captured as value-added in Equations 1 and 2. **TQ** is a vector of observable teacher characteristics typically used to measure teacher quality. This vector includes experience, experience squared, certification route, Praxis I test scores, Praxis II professional knowledge test scores, and graduate degrees. Teacher characteristics, **TC**, are controlled for in a vector of teacher demographics including race and gender. We use binary indicators for each year. Note that because our dependent variable in this stage is for the entire grade at the school, we see the same dependent variable measure for each teacher within a school-grade, and the number of times we see it varies with the number of teachers per grade at the school. For this reason, we cluster error terms by school and grade to estimate standard errors more accurately.

Table 4. Comparison of School Districts With Nontraditional Teachers, 2008.

Characteristic	Districts with a nontraditional teacher	Districts without a nontraditional teacher
No. of districts	123	101
Percent proficient or advanced–math	73%	72%
Percent proficient or advanced–ELA	68%	67%
Average enrollment	2,517	910
Percent FRL	60%	59%
Percent minority	26%	20%

Note. ELA = English language arts; FRL = Free or reduced price lunch.

One potential criticism of our analyses might pertain to the distribution of alternatively certified teachers among all of the various schools in the state. That is, if a certain type of district or school is more likely to hire alternatively certified teachers, we might expect our results to be biased. As it stands, alternatively certified teachers in our least restrictive math sample were teachers of record in a total of 249 schools and 138 districts over the course of the years included in our data. Thus alternatively certified teachers were in more than a quarter of all schools with students in Grades 3 through 8 and more than half of all districts. Moreover, these teachers were located in all areas of the state. The vast majority of these schools, more than 78%, had only one or two alternatively certified teachers in a given year. Only 5% of the schools had five or more alternatively certified teachers in a given year, with seven teachers being the max. Using 2008 data, we compared districts with an alternatively certified teacher with districts that did not have an alternatively certified teacher (see Table 4). Districts with alternatively certified teachers were significantly larger ($p < .01$) and had marginally higher percentages of minority students ($p < .10$), on average. However, there was not a significant difference in the percentage of students scoring proficient or advanced on state tests in math or language arts or in the percentage of students receiving free or reduced price lunches. For these reasons, we do not believe that the dispersion of alternatively certified teachers among schools biases our results.

Analysis

In our analysis, we link students and teachers to a specific grade in a school. Using a variety of state administrative data, we are able to analyze the impact of various observable teacher characteristics on student achievement. Prospective teachers are required to pass an examination of basic skills (Praxis I), a test of professional knowledge (Praxis II), and a content knowledge test (Praxis II). We observe Praxis I and Praxis II (professional knowledge) test scores, the teacher's route to certification (traditional or alternative), and whether the teacher has an advanced degree. Advanced degrees, along with years of experience, are the sole drivers in teacher compensation throughout most of the state. We standardize all student test scores.

As we are unable to match teachers to students, we analyze teacher impacts on student achievement in a number of ways to provide a series of robustness checks regarding our two research questions. We start with the largest possible sample of teachers and then narrow the sample in subsequent analyses. Using job codes provided by the state, we are able to identify what subject a teacher teaches. The first set of analyses includes all teachers who might reasonably contribute to a student's learning in math or language arts, which we believe includes any core subject teacher. Thus, we include all teachers with a job code for math and language arts, as well as teachers who taught science and social studies (school-grade). In our second set of analyses we remove teachers who do not teach the specific subject being tested, leaving only teachers with a math job code in our math analyses and language arts in our language arts analyses (school-grade-subject). As we noted, alternatively certified teachers tend to have less experience. Therefore, we limit our next sample to all teachers of core subjects in their first 5 years of teaching (school-grade-novice). In this set of analyses and each subsequent set, we conduct our analyses using the school-grade sample that includes all core subject teachers. We conduct additional analyses to estimate whether the teachers further from the mean in terms of their licensure exam score disproportionately impact student achievement.

Although we have data on three sections of the Praxis I test, reading, writing, and math, in addition to scores on the professional knowledge exam, we find few variables to be significant when we utilize all of the variables in our models because of collinearity. In fact, many of the explanatory variables are highly colinear. Appendix A displays the correlation coefficients between our teacher test data, race, and gender with the probability of independent distributions in parenthesis below the correlation coefficients. We also include a Praxis I variable, which is a composite score created by taking an average of the three Praxis I subtests. The Praxis II test is highly correlated with each section of the Praxis I and even more so with the Praxis I composite score. This may be expected as people who are knowledgeable and/or test well would be expected to perform well on all Praxis I and II exams. Notably, race is also significantly correlated with each test. As we know from national and Arkansas education data, there is an achievement gap between White and minority students, and we believe that this is displayed by the disparate average performance of White and minority teachers in Arkansas. Moreover, close to 90% of teachers in our sample are White. Indeed, when we place a race indicator in our model, it is significant due to correlation with our other variables. Thus, we remove the race indicator from our models.

School-Grade Analyses

As mentioned above, our first set of analyses attribute the value-added to all teachers of core subjects at a specific grade within a school. We display the regression results for the school-grade level math analyses in Table 5 and ELA in Table 6. In each analysis, we cluster error terms at the school-grade level. The sample sizes range from 17,196 teachers in our least restrictive sample to 5,567 in both math and ELA. In addition to the analyses presented, we limited our sample to only teachers with 20 or fewer years of experience. We do not display the results, because they were not significantly different from what we have presented here.

It is clear from these analyses that teachers who score higher on licensure exams tend to perform better in terms of raising student achievement. And at first glance, alternatively certified teachers seem to be significantly lower performing than traditionally certified teachers. In each model in both math and ELA, the coefficient on alternative certification is negative; however, the coefficient is only significant when the teacher's performance on licensure exams is controlled for in the model. Controlling for licensure scores is inappropriate as licensure exam scores are significantly correlated with licensure route. Alternatively certified teachers in our sample score significantly higher on licensure exams. Indeed, one of the promises of alternative certification is the potential of drawing high-performing individuals into the classroom.

Though we find little evidence of increased effectiveness from additional experience as a whole, it is marginally significant in one math model and significant in one ELA model, we do find that alternatively certified teachers seem to improve more rapidly. We include an interaction term for alternative certification and years of experience. The coefficient on the interaction term is positive and statistically significant or marginally significant in each model in both subject areas. Most alternatively certified teachers enter the classroom with little to no experience actually teaching, while traditionally certified teachers have a student teaching experience prior to entering the classroom as a teacher of record. Thus, it may be expected that alternatively certified teachers would benefit more from an additional year of experience.

School-Grade-Subject Analyses

To get a more direct match of teachers to students in the tested areas, we limit the teachers in our sample to only those listed as a math or language arts

Table 5. Math School-Grade-Level Results With Clustered Error Terms.

Variables	(1)	(2)	(3)	(4)	(5)
Praxis II			0.0126***	0.0154***	0.0154***
			[0.00248]	[0.00481]	[0.00483]
Praxis I		0.0104***		0.000212	0.000170
		[0.00394]		[0.00491]	[0.00492]
Alternative certification	−0.0109	−0.0177*	−0.0206**	−0.0268**	−0.0260**
	[0.00884]	[0.0105]	[0.0102]	[0.0117]	[0.0128]
BA not earned in Arkansas	−0.00292	0.000426	−0.00856	−0.00690	−0.00701
	[0.00521]	[0.0139]	[0.00602]	[0.0143]	[0.0143]
Graduate degree	0.000532	−0.00685	−0.00281	−0.00877	−0.00846
	[0.00394]	[0.00589]	[0.00435]	[0.00597]	[0.00631]
Alternative certification/graduate degree interaction term					−0.00368
					[0.0199]
Experience	0.00108	0.00343*	0.000990	0.00250	0.00250
	[0.000693]	[0.00202]	[0.000746]	[0.00213]	[0.00213]
Experience squared	−5.02e-05**	−0.000214	−4.43e-05*	−0.000161	−0.000161
	[2.15e-05]	[0.000148]	[2.48e-05]	[0.000153]	[0.000153]
Alternative certification/experience interaction term	0.00560**	0.00526*	0.00484*	0.00575*	0.00580*
	[0.00261]	[0.00290]	[0.00291]	[0.00310]	[0.00309]
2007	0.0141**	0.0121*	0.0131**	0.0117*	0.0117*
	[0.00560]	[0.00648]	[0.00545]	[0.00638]	[0.00637]
2008	0.0167**	0.0124*	0.0161**	0.0124*	0.0124*
	[0.00657]	[0.00745]	[0.00629]	[0.00729]	[0.00729]
Female	0.00622	0.0151**	0.00769	0.0107*	0.0106*
	[0.00438]	[0.00606]	[0.00489]	[0.00630]	[0.00630]
Constant	−0.0151*	−0.0209**	−0.0136*	−0.0142	−0.0142
	[0.00792]	[0.0101]	[0.00784]	[0.0104]	[0.0104]
Observations	17,196	5,916	13,407	5,567	5,567
R^2	.005	.008	.009	.012	.012

Note. Standard errors are given in brackets.
*$p < .10$. **$p < .05$. ***$p < .01$.

teacher. This considerably lowers the number of teachers in our analysis, but potentially provides a more accurate assessment of the teacher's impact on student achievement (see Appendices B and C). As before, we find a significant positive relationship between a teacher's performance on the Praxis II professional knowledge exam and student achievement in math ($p < .01$); however, the exam is not statistically significant in ELA. When we restrict our sample to only teachers of the tested subjects, alternatively certified teachers are not statistically different from traditionally certified teachers in any of the models.

Table 6. Language Arts School-Grade-Level Results With Clustered Error Terms.

Variables	(1)	(2)	(3)	(4)	(5)
Praxis II			0.00720***	0.00636*	0.00680*
			[0.00189]	[0.00367]	[0.00371]
Praxis I		0.00758***		0.00394	0.00360
		[0.00282]		[0.00364]	[0.00366]
Alternative certification	−0.00875	−0.0174**	−0.0138*	−0.0187**	−0.0126
	[0.00673]	[0.00755]	[0.00761]	[0.00854]	[0.00907]
BA not earned in Arkansas	−0.000302	0.00765	−0.00235	0.00395	0.00300
	[0.00384]	[0.00992]	[0.00445]	[0.0109]	[0.0109]
Graduate degree	0.00127	−0.00419	3.07e−05	−0.00570	−0.00321
	[0.00268]	[0.00417]	[0.00309]	[0.00432]	[0.00457]
Alternative certification/graduate degree interaction term					−0.0297*
					[0.0161]
Experience	0.000919**	0.000802	0.000612	0.000312	0.000314
	[0.000455]	[0.00122]	[0.000518]	[0.00130]	[0.00130]
Experience squared	−2.67e-05*	−1.06e-05	−7.94e-06	2.08e-05	2.08e-05
	[1.40e-05]	[8.48e-05]	[1.77e-05]	[8.91e-05]	[8.95e-05]
Alternative certification/ experience interaction term	0.00410**	0.00528**	0.00439**	0.00491**	0.00528**
	[0.00205]	[0.00219]	[0.00215]	[0.00229]	[0.00235]
2007	0.00362	0.00121	0.00204	0.000471	0.000322
	[0.00373]	[0.00426]	[0.00380]	[0.00434]	[0.00433]
2008	−0.000482	−0.000755	−0.00205	−0.000726	−0.000761
	[0.00451]	[0.00525]	[0.00448]	[0.00529]	[0.00527]
Female	0.00774**	0.00919**	0.00359	0.00593	0.00534
	[0.00338]	[0.00451]	[0.00362]	[0.00471]	[0.00469]
Constant	−0.0106*	−0.00944	−0.00479	−0.00513	−0.00550
	[0.00563]	[0.00698]	[0.00566]	[0.00722]	[0.00726]
Observations	17,196	5,916	13,407	5,567	5,567
R^2	.002	.007	.005	.008	.009

Note. Standard errors are given in brackets.
*$p < .10$. **$p < .05$. ***$p < .01$.

School-Grade-Novice Analyses

As we noted in Table 3, traditionally certified teachers in our sample have much more experience than nontraditionally licensed teachers, an average of 12.9 years compared with 1.8 years. We conduct additional analyses to take into account the varying levels of experience. Essentially, we want to compare new nontraditional teachers with new traditional teachers. We do this by limiting our sample to teachers within their first 5 years of experience. Once again, the results for math and language arts are for the most part consistent with the above analyses (see Appendices D and E). Praxis II scores remain our strongest predictor of performance in both subjects. The coefficients on alternative certification remain negative in each model, but are only marginally significant in one math model and significant ($p < .05$) in two ELA models. Again, the difference between traditionally and alternatively certified teachers is only significant when licensure exam scores are included in the model.

Teachers in the Tails

The above analyses suggest that teacher performance on licensure exams, particularly the Praxis II content knowledge exam, is significantly correlated with student achievement. We want to test whether teachers in the tails of the distribution disproportionately impact student achievement. We create indicator variables for teachers in the top and bottom 10% and top and bottom 25% in terms of performance on the Praxis I and II. We then replicate the previously presented analyses with indicators for teachers with Praxis I or II score in top or bottom of the distribution (see Appendices F and G). As expected, higher scoring teachers tend to be significantly more effective at increasing student achievement in both subjects, although statistical significance is detected more readily in math.

Discussion and Policy Implications

Ensuring that students have a quality teacher is a worthy endeavor. To do this, Arkansas, like most states, has instituted a licensure system whereby teachers must pass a series of examinations to earn a teaching license. The traditional route requires a degree in education, student teaching, and passage of the licensure tests. The alternative route allows individuals with any degree who pass the licensure exams and find a job to enter the classroom without a student teaching experience. In this article, we ask two fundamental questions regarding the licensure process: (a) Do traditionally certified teachers increase student achievement on standardized exams in math and language arts differently than alternatively certified teachers? (b) Do teachers with higher scores on licensure exams increase student achievement differently than lower scoring teachers? These research questions give us some indication whether our current licensure screens are predictors of quality.

To answer these questions, we utilize a two-step approach. First, we estimate student value-added with a parsimonious model, controlling for 2 years of achievement data in math and ELA. We attribute the value-added to teachers at a school-grade level and regress on observable teacher characteristics, including licensure exam scores and licensure route. We conduct a series of robustness checks.

It is important to remember that licensure exams were not intended to be predictors of performance in the classroom; rather they are a minimum quality guard. Thus, they weed out extremely low performers. In addition, as they are designed around a cut point, some tests have ceiling effects. Still, performance on licensure exams, especially the Praxis II, tends to be a significant predictor of future performance. This is in accord with a wide literature base that suggests that teachers with more content knowledge or higher prior academic achievement tend to be more effective teachers. We suspect that a test designed to capture a full range of abilities among prospective teachers may have an even better predictive power.

Certification route, however, does not provide clear results. On average, alternatively certified teachers tend to perform slightly lower than traditionally certified teachers, but there is more variation within each group than between groups. Furthermore, the differences between groups tend to be small and marginally significant only when we control for prior academic achievement as measured by teacher licensure exams. Because alternatively certified teachers score significantly higher on licensure exams, on average, including these scores biases the estimates of alternative certification downward. Nevertheless, the coefficient on alternative certification remains negative, but insignificant, when teacher test scores are not included. We conclude that traditionally certified teachers gain some experience through their training program, which translates to close to a year of experience. Alternatively certified teachers seem to make up the difference as they gain from years of experience at a more rapid rate than traditionally certified teachers. To explore this a bit more, we conduct an additional set of analyses (not presented) where we control for the extra experience of traditionally certified teachers. We do this by adding an extra year of experience to only traditionally certified teachers. This results in a positive, but insignificant, coefficient on alternative certification, which would indicate that the difference between the two groups is less than a year of experience.

One of the promises of alternative certification is the ability to bring high-performing individuals from other fields into teaching, without requiring them to get an education degree. From our analyses, this seems to be happening. The individuals entering the profession via an alternative route score higher on licensure exams. This is not out of the ordinary. In New York, "only 5 percent of newly hired Teaching Fellows and TFA teachers in 2003 failed the LAST [Liberal Arts and Sciences Test] exam on their first attempt, while 16.2 percent of newly hired traditional teachers failed the LAST exam" (Boyd et al., 2008, p. 815). The alternatively certified teachers in our sample are also significantly more likely to be male. Thus, the alternative licensure route seems to be attracting above-average individuals, in terms of licensure exam scores, and males into elementary classrooms.

When policymakers develop, or tinker with, a teacher licensure system, they must be aware of the trade-offs. Creating a narrow route to certification, like the traditional route, or increasing licensure exam requirements will keep out some individuals who may be highly effective teachers. This seems evident from our analyses as high-performing individuals, in terms of licensure scores and value-added, are now entering the teacher workforce via alternative routes. Though they lack the pedagogical training and student teaching experience, on average, these individuals perform similarly to traditionally certified teachers. In other words, exceptional teachers and low-performing teachers enter the profession from both routes.

Based on the evidence presented here and existing literature on teacher certification, it may be prudent for states to revisit their licensure practices. Traditional education certification seems to be restricting high-ability entrants into the field. Rather than restricting licensure to only teachers who have been traditionally trained, raising licensure exams score requirements, or requiring alternatively certified teachers to take additional courses, states should make entering the teaching profession for individuals easier and weed out the ones who are low performing. One potential way of doing this is by enabling school districts to be certification authorizers. In this model, individuals would obtain a temporary teaching permit, which would enable them to teach for 2 to 3 years. Of course, school districts would then need to use diligence when hiring teachers to keep any truly unqualified individual from the classroom. On the completion of the temporary teaching term, school districts could recommend the teacher for full certification or for an extended permit, not to exceed a specified number of years.

This model holds much promise for improving the quality of the teacher workforce. After all, schools and their students have the most to gain from having highly capable teachers in the classroom. It makes sense then to allow schools some authority in determining which teachers are truly qualified to teach, rather than have the state eliminate some potentially terrific teachers based on arbitrary cut scores on licensure exams or because they have not taken the right coursework.

Quality teachers simply cannot be identified exclusively by their licensure route or their exam scores. It seems that there is something unobservable about an individual that makes him or her an effective teacher. We are left then with two real possibilities, improve licensure screens to the point that we can identify teacher quality very accurately or allow schools to use reasonable screens and identify quality teachers in practice. The former seems improbable. Therefore, we believe teachers, and students, would be best served by equipping schools with more authority to hire the individuals they believe are qualified for the job and to certify those individuals who meet expectations in the classroom.

Limitations and Suggestions for Future Research

Of course, there are limitations to our research that do warrant caution. First and foremost is our inability to link students to teachers. Our methods do not bias the results, but do make detecting a significant difference between traditionally and alternatively certified teachers more difficult. Moreover, it makes the estimates of a particular variable's impact less precise. Future research should attempt to match teachers to students.

This study adds to the existing literature and the results here are consistent with the findings in other locations. Like New York City, however, Arkansas is not representative of the entire country. Additional studies should be conducted in Arkansas and in other states with rural populations.

Appendix A

Correlation Matrix Using Least Restrictive School-Grade Math Sample

	Praxis I	Praxis II	Praxis I–Math	Praxis I–Reading	Praxis I–Writing	White
Praxis I	1.0000					
Praxis II	.6083	1.0000				
	.0000					
Praxis I–Math	.8095	.4269	1.000			
	.0000	.0000				
Praxis I–Reading	.8358	.5825	.5238	1.0000		
	.0000	.0000	.0000			
Praxis I–Writing	.7847	.4732	.4151	.5147	1.0000	
	.0000	.0000	.0000	.0000		
White	.2201	.2340	.1891	.1907	.1537	1.0000
	.0000	.0000	.0000	.0000	.0000	

Appendix B

Math School-Grade-Subject Level Results With Clustered Error Terms

Variables	(1)	(2)	(3)	(4)	(5)
Praxis II			0.0172***	0.0182**	0.0177**
			[0.00452]	[0.00893]	[0.00897]
Praxis I		0.0134**		0.00170	0.00233
		[0.00677]		[0.00874]	[0.00884]
Alternative certification	−0.0106	0.00612	−0.0197	−0.00189	−0.00699
	[0.0161]	[0.0182]	[0.0183]	[0.0199]	[0.0205]
BA not earned in Arkansas	−0.0153*	−0.0403*	−0.0203**	−0.0393	−0.0390
	[0.00809]	[0.0226]	[0.0104]	[0.0243]	[0.0241]
Graduate degree	0.0114	0.00291	0.00885	0.00213	−0.000481
	[0.00736]	[0.0107]	[0.00829]	[0.0109]	[0.0112]
Alternative certification/graduate degree interaction					0.0305
					[0.0394]
Experience	−0.000843	0.00728**	−0.000524	0.00677*	0.00676*
	[0.00109]	[0.00365]	[0.00131]	[0.00373]	[0.00372]
Experience squared	−9.33e-06	−0.000370	−2.19e-05	−0.000353	−0.000351
	[3.36e-05]	[0.000277]	[4.42e-05]	[0.000280]	[0.000280]
Alternative certification/experience interaction	0.00362	0.000489	0.00652	0.00368	0.00289
	[0.00421]	[0.00475]	[0.00430]	[0.00478]	[0.00463]
2007	0.0202***	0.0181*	0.0229***	0.0179*	0.0179*
	[0.00762]	[0.0100]	[0.00824]	[0.0100]	[0.0100]
2008	0.0238***	0.0224**	0.0252***	0.0197*	0.0197*
	[0.00813]	[0.0106]	[0.00862]	[0.0108]	[0.0108]
Female	0.0413***	0.0424***	0.0452***	0.0355***	0.0364***
	[0.00753]	[0.0113]	[0.00888]	[0.0120]	[0.0121]
Constant	−0.0304***	−0.0531***	−0.0347***	−0.0447**	−0.0445**
	[0.0109]	[0.0170]	[0.0124]	[0.0178]	[0.0177]
Observations	4,620	1,669	3,704	1,591	1,591
R^2	.019	.029	.029	.033	.034

Note. Standard errors are given in brackets.
*$p < .10$. **$p < .05$. ***$p < .01$.

Appendix C

Language Arts School-Grade-Subject Level Results With Clustered Error Terms

Variables	(1)	(2)	(3)	(4)	(5)
Praxis II			0.00477	−0.00343	−0.00341
			[0.00293]	[0.00671]	[0.00663]
Praxis I		0.00735		0.00909	0.00883
		[0.00507]		[0.00653]	[0.00650]
Alternative certification	−0.0206	−0.0252	−0.0258	−0.0285	−0.0145
	[0.0145]	[0.0159]	[0.0168]	[0.0191]	[0.0205]
BA not earned in Arkansas	0.00500	0.00597	0.00495	−0.0184	−0.0194
	[0.00525]	[0.0175]	[0.00633]	[0.0181]	[0.0187]
Graduate degree	0.000777	0.000164	0.00113	−0.00369	−0.000339
	[0.00453]	[0.00744]	[0.00527]	[0.00771]	[0.00777]
Alternative certification/graduate degree interaction term					−0.0661*
					[0.0361]
Experience	7.23e−05	0.00125	−0.000249	0.000331	0.000379
	[0.000726]	[0.00225]	[0.000902]	[0.00222]	[0.00223]
Experience squared	−5.89e-06	−2.24e-05	1.80e-05	3.17e-05	2.95e-05
	[2.22e-05]	[0.000161]	[3.08e-05]	[0.000157]	[0.000157]
Alternative certification/ experience interaction term	0.00402	0.00566	0.000604	0.00168	0.00149
	[0.00578]	[0.00646]	[0.00687]	[0.00715]	[0.00716]
2007	0.00670	0.00649	0.00665	0.00642	0.00627
	[0.00550]	[0.00730]	[0.00584]	[0.00753]	[0.00748]
2008	0.00750	0.00968	0.00717	0.0119	0.0120
	[0.00604]	[0.00828]	[0.00629]	[0.00828]	[0.00822]
Female	0.0141*	0.0192	0.0152	0.0264*	0.0260*
	[0.00796]	[0.0130]	[0.00926]	[0.0139]	[0.0140]
Constant	−0.0140	−0.0273*	−0.0157	−0.0293*	−0.0304**
	[0.0102]	[0.0145]	[0.0111]	[0.0151]	[0.0151]
Observations	5,789	1,874	4,523	1,737	1,737
R^2	.003	.010	.005	.014	.017

Note. Standard errors are given in brackets.
*p < .10. **p < .05. ***p < .01.

Appendix D

Math School-Grade Level Results for Novice Teachers With Clustered Error Terms

Variables	(1)	(2)	(3)	(4)	(5)
Praxis II			0.0141***	0.0197***	0.0199***
			[0.00417]	[0.00615]	[0.00618]
Praxis I		0.0178***		0.00671	0.00657
		[0.00550]		[0.00646]	[0.00646]
Alternative certification	−0.00114	−0.0144	−0.0128	−0.0247*	−0.0227
	[0.0108]	[0.0122]	[0.0117]	[0.0129]	[0.0139]
BA not earned in Arkansas	0.00620	0.00334	0.00945	−0.00328	−0.00371
	[0.00778]	[0.0169]	[0.00988]	[0.0180]	[0.0180]
Graduate degree	0.000722	−0.00404	−0.00278	−0.00827	−0.00683
	[0.00625]	[0.00776]	[0.00655]	[0.00789]	[0.00871]
Alternative certification/graduate degree interaction term					−0.00918
					[0.0213]
Experience	0.00774	0.00452	0.00381	−0.00189	−0.00193
	[0.00528]	[0.00624]	[0.00554]	[0.00648]	[0.00649]
Experience squared	−0.00113	−0.000736	−0.000562	0.000225	0.000234
	[0.00104]	[0.00125]	[0.00104]	[0.00128]	[0.00128]
Alternative certification/experience interaction term	−0.000883	0.000709	−0.00224	0.00224	0.00236
	[0.00505]	[0.00552]	[0.00532]	[0.00578]	[0.00581]
2007	0.0173**	0.0182**	0.0155**	0.0172*	0.0172*
	[0.00745]	[0.00890]	[0.00753]	[0.00882]	[0.00881]
2008	0.0208**	0.0195**	0.0208**	0.0195**	0.0195**
	[0.00859]	[0.00985]	[0.00849]	[0.00970]	[0.00970]
Female	0.00534	0.00936	0.00385	0.00508	0.00483
	[0.00652]	[0.00812]	[0.00747]	[0.00874]	[0.00877]
Constant	−0.0253**	−0.0232*	−0.0176	−0.0111	−0.0113
	[0.0109]	[0.0125]	[0.0116]	[0.0132]	[0.0132]
Observations	5,819	3,143	4,791	2,825	2,825
R^2	.005	.010	.010	.019	.019

Note. Standard errors are given in brackets.
*p < .10. **p < .05. ***p < .01.

Appendix E

Lit School-Grade Level Results for Novice Teachers With Clustered Error Terms

Variables	(1)	(2)	(3)	(4)	(5)
Praxis II			0.00720***	0.00636*	0.00680*
			[0.00189]	[0.00367]	[0.00371]
Praxis I		0.00758***		0.00394	0.00360
		[0.00282]		[0.00364]	[0.00366]
Alternative certification	−0.00875	−0.0174**	−0.0138*	−0.0187**	−0.0126
	[0.00673]	[0.00755]	[0.00761]	[0.00854]	[0.00907]
BA not earned in Arkansas	−0.000302	0.00765	−0.00235	0.00395	0.00300
	[0.00384]	[0.00992]	[0.00445]	[0.0109]	[0.0109]
Graduate degree	0.00127	−0.00419	3.07e−05	−0.00570	−0.00321
	[0.00268]	[0.00417]	[0.00309]	[0.00432]	[0.00457]
Alternative certification/graduate degree interaction term					−0.0297*
					[0.0161]
Experience	0.000919**	0.000802	0.000612	0.000312	0.000314
	[0.000455]	[0.00122]	[0.000518]	[0.00130]	[0.00130]
Experience squared	−2.67e-05*	−1.06e-05	−7.94e-06	2.08e-05	2.08e-05
	[1.40e-05]	[8.48e-05]	[1.77e-05]	[8.91e-05]	[8.95e-05]
Alternative certification/ experience interaction term	0.00410**	0.00528**	0.00439**	0.00491**	0.00528**
	[0.00205]	[0.00219]	[0.00215]	[0.00229]	[0.00235]
2007	0.00362	0.00121	0.00204	0.000471	0.000322
	[0.00373]	[0.00426]	[0.00380]	[0.00434]	[0.00433]
2008	−0.000482	−0.000755	−0.00205	−0.000726	−0.000761
	[0.00451]	[0.00525]	[0.00448]	[0.00529]	[0.00527]
Female	0.00774**	0.00919**	0.00359	0.00593	0.00534
	[0.00338]	[0.00451]	[0.00362]	[0.00471]	[0.00469]
Constant	−0.0106*	−0.00944	−0.00479	−0.00513	−0.00550
	[0.00563]	[0.00698]	[0.00566]	[0.00722]	[0.00726]
Observations	17,196	5,916	13,407	5,567	5,567
R^2	.002	.007	.005	.008	.009

Note. Standard errors are given in brackets.
**p* < .10. ***p* < .05. ****p* < .01.

Appendix F

Math Testing Tails, School-Grade Level Results With Clustered Error Terms

Variables	Praxis I–10%	Praxis I–25%	Praxis II–10%	Praxis II–25%
Licensure test-top	0.0183*	0.0132**	0.0169***	0.00804*
	[0.00993]	[0.00657]	[0.00628]	[0.00430]
Licensure test-bottom	−0.0176**	−0.00134	−0.0274***	−0.0157***
	[0.00786]	[0.00660]	[0.00596]	[0.00450]
Alternative certification	−0.0172	−0.0169	−0.0201**	−0.0201**
	[0.0105]	[0.0105]	[0.0102]	[0.0102]
BA not earned in Arkansas	−0.000326	0.000828	−0.00781	−0.00770
	[0.0137]	[0.0139]	[0.00598]	[0.00601]
Graduate degree	−0.00659	−0.00664	−0.00231	−0.00246
	[0.00587]	[0.00590]	[0.00434]	[0.00434]
Experience	0.00332*	0.00318	0.00101	0.000991
	[0.00201]	[0.00203]	[0.000743]	[0.000746]
Experience squared	−0.000208	−0.000206	−4.39e-05*	−4.56e-05*
	[0.000147]	[0.000149]	[2.47e-05]	[2.49e-05]
Alternative certification/experience	0.00541*	0.00538*	0.00453	0.00496*
interaction term	[0.00288]	[0.00290]	[0.00287]	[0.00290]
2007	0.0122*	0.0123*	0.0131**	0.0132**
	[0.00649]	[0.00649]	[0.00545]	[0.00545]
2008	0.0126*	0.0126*	0.0159**	0.0162**
	[0.00745]	[0.00746]	[0.00630]	[0.00630]
Female	0.0147**	0.0144**	0.00964**	0.00858*
	[0.00606]	[0.00606]	[0.00486]	[0.00489]
Constant	−0.0202**	−0.0225**	−0.0148*	−0.0128
	[0.0101]	[0.0104]	[0.00784]	[0.00799]
Observations	5,916	5,916	13,407	13,407
R^2	.008	.007	.009	.007

Note. Standard errors are given in brackets.
*p < .10. **p < .05. ***p < .01.

Appendix G

Lit Testing Tails, School-Grade Level Results With Clustered Error Terms

Variables	Praxis I–10%	Praxis I–25%	Praxis II–10%	Praxis II–25%
Licensure test-top	0.00841	0.0104**	0.00858*	0.00428
	[0.00665]	[0.00470]	[0.00451]	[0.00330]
Licensure test-bottom	−0.0158***	0.00221	−0.0138***	−0.00841**
	[0.00580]	[0.00484]	[0.00456]	[0.00340]
Alternative certification	−0.0170**	−0.0166**	−0.0134*	−0.0135*
	[0.00758]	[0.00755]	[0.00763]	[0.00760]
BA not earned in Arkansas	0.00799	0.00795	−0.00180	−0.00179
	[0.00988]	[0.00996]	[0.00444]	[0.00444]
Graduate degree	−0.00403	−0.00401	0.000391	0.000280
	[0.00417]	[0.00417]	[0.00307]	[0.00308]
Experience	0.000689	0.000550	0.000602	0.000602
	[0.00121]	[0.00121]	[0.000516]	[0.000519]
Experience squared	−3.11e-06	−3.16e-06	−7.32e-06	−8.40e-06
	[8.42e-05]	[8.36e-05]	[1.76e-05]	[1.77e-05]
Alternative certification/experience interaction term	0.00537**	0.00540**	0.00422*	0.00445**
	[0.00220]	[0.00218]	[0.00216]	[0.00213]
2007	0.00115	0.00135	0.00203	0.00207
	[0.00426]	[0.00426]	[0.00381]	[0.00380]
2008	−0.000711	−0.000510	−0.00213	−0.00198
	[0.00525]	[0.00525]	[0.00449]	[0.00449]
Female	0.00904**	0.00848*	0.00483	0.00421
	[0.00453]	[0.00451]	[0.00358]	[0.00362]
Constant	−0.00823	−0.0112	−0.00560	−0.00445
	[0.00711]	[0.00716]	[0.00565]	[0.00582]
Observations	5,916	5,916	13,407	13,407
R^2	.007	.006	.004	.004

Note. Standard errors are given in brackets.
*$p < .10$. **$p < .05$. ***$p < .01$.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Note

1. Bimodal distributions were detected for some test codes. Because the test codes with bimodal distributions represent more than 12% of all test scores, we split bimodal test codes into two distributions. The scores are then normalized over the relative subset. Scores are then winsorized to reduce the effects of outliers by replacing outlier variables rather than eliminating observations from the data. The outliers are replaced, rather than eliminated, with the standardized scores at the 1st and 99th percentiles.

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Author Biographies

James V. Shuls is an education policy analyst at the Show-Me institute. He earned his PhD in education policy from the University of Arkansas.

Julie R. Trivitt is a clinical assistant professor of business in the Walton College of Business and an adjunct assistant professor in the Department of Education Reform at the University of Arkansas.