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Does Teacher Certification Matter? Evaluating the Evidence

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The authors respond to Dan Goldhaber and Dominic Brewer's article in the Summer 2000 issue of Educational Evaluation and Policy Analysis *that claimed from an analysis of NELS teacher and student data that teacher certification has little bearing on student achievement. Goldhaber and Brewer found strong and consistent evidence that, as compared with students whose teachers are uncertified, students achieve at higher levels in mathematics when they have teachers who hold standard certification in mathematics. (The same was true to a somewhat lesser extent in science.) However, they emphasized their finding that, "Contrary to conventional wisdom, mathematics and science [students] who have teachers with emergency credentials do no worse than students whose teachers have standard teaching credentials" and suggested that certification be abandoned. This article critiques the methodological grounding for this finding and presents additional data on the characteristics of the small sub-sample of teachers in NELS data base who held temporary and emergency credentials. It finds that most of these teachers have qualifications resembling those of teachers with standard certification, and that those who have more education training appear to do better in producing student achievement. It also reviews the literature on teacher education and certification as the basis for evaluating Goldhaber and Brewer's claim that states should eliminate certification requirements and proposes additional research that would illuminate how teacher education and certification operate—and could better operate—to enable teachers to succeed in their work.*

In their article in the Summer 2000 issue of *Educational Evaluation and Policy Analysis*, Dan Goldhaber and Dominic Brewer reported on a study using the NELS:88 data base to examine how teachers' training relates to student achievement. Their analyses explored how teacher certification and other training-related variables appear to influence 12th grade student achievement in mathematics and science, after controlling for a range of student background factors, including 10th grade scores. The study represents an interesting use of one of the few national data sets that allows longitudinal assessment of student learning in relation to characteristics of their teachers and schools. The analysis adds to a growing literature that considers aspects of teachers' preparation as possible determinants of student achievement.

The authors found strong and consistent evidence that, as compared with students whose teachers are uncertified, students achieve at higher levels in mathematics when they have teachers who hold standard certification in mathematics; the same finding held to a lesser extent in science. However, they also found that, "Contrary to conventional wisdom, mathematics and science [students] who have teachers with emergency credentials do no worse than students whose teachers have standard teaching credentials." Based on this finding, Goldhaber and Brewer ultimately concluded that certification should not be required for teachers.

This finding, which is highlighted several times in the report of their study, is based on non-significant regression coefficients (both positive and negative) that attach to a tiny group of 24 science teachers and 34 math teachers who had students tested in grades 10 and 12 in the NELS data base and who held temporary or emergency certification—a minute share of the overall sample of 3,469 math and science teachers included in their analysis. The authors make extraordinarily strong policy claims based on a small sub-sample vulnerable to large sampling error in a correlational analysis that included many other variables collinear with certification. They state that

> This result, should, at the very least, cast doubt on the claims of the educational establishment that standard certification should be required of all teachers. In fact, we believe it is incumbent on those who expound such a position to demonstrate that such training systematically leads to better teachers; in our data we find little evidence for this position (p. 141).

In drawing its conclusions, the article ignores its own findings about the positive effects of teacher certification on student achievement (based on the 2,800 teachers who held such certification in their sample) while resting sweeping policy recommendations on a finding from a sub-sample too small to support ambitious inferences. The study's problematic conclusions derive not only from over-generalization based on tenuous evidence but also from a misunderstanding of how state certification systems operate; a failure to examine the available data on the emergency certified teachers in question (a large share of whom are similarly prepared to those with standard certification); and a neglect of much of the existing research in the field. The authors ignore methodologically solid work that would lead to different conclusions about the effects of preparation, while referencing studies that are methodologically inadequate to support conclusions about the effects of preparation or certification.

The article, which was funded by the Thomas B. Fordham Foundation, an organization that advocates the elimination of teacher certification requirements (Thomas B. Fordham Foundation, 1999), creates a straw man argument about the views of the "education establishment" that reduces the complex issues of teacher licensure to a set of simplistic claims. This is especially unfortunate given the seriousness of the topic and the critical need for useful research in this area. In what follows, we present data on each of these points and suggest a research agenda that would move our understanding of teacher quality forward more productively.

In the first section, we review and critique the study's methods and findings. We then describe state licensing rules to illuminate the qualifications generally attained by teachers who hold temporary or emergency licenses in different states. The third section presents more detailed data on the qualifications of teachers in the NELS sample who held temporary or emergency certification. The fourth section reviews other research on teacher education and certification, including studies mentioned by Goldhaber and Brewer in support of their conclusions. The final section discusses research that could move the field beyond over-simplified debates on the value of certification to more nuanced discussions of the kinds of preparation that matter for teacher quality and effectiveness.

The Goldhaber and Brewer Study

What the Study Examined and What it Found

Using the NELS: 88 surveys that followed 8th graders in 1988 through 12th grade in 1992, Goldhaber and Brewer examined how teacher certification and other training-related variables influenced 12th grade student achievement in mathematics and science, controlling for a range of student background factors including 10th grade scores. The overall strategy is a useful one; however, some methodological problems could distort the results. First, the analyses did not use the NELS sample weights for student and teacher data; thus, it did not take into account the over-sampling of certain strata in the survey design or the nested nature of the NELS samples resulting from the clustering of students and teachers within classrooms and schools. Second, the analyses use a large number of variables, many of which are highly correlated, without appearing to take issues of multicollinearity into account in selecting variables or interpreting results. Third, the construction of overlapping variables to capture teachers' training is problematic, as discussed below. We cannot fully predict the ways in which these limitations affect the results. We note them here so that they may be taken into account in future research.

The authors find that student achievement is positively influenced by having a teacher who holds a BA or MA degree in mathematics. Having a certified teacher in mathematics exerts an even stronger

positive influence on student achievement. The same trends are true in science, but the influences are weaker. They state:

> [W]e find that the type (standard, emergency, etc.) of certification a teacher holds is an important determinant of student outcomes. In mathematics, we find the students of teachers who are either not certified in their subject (in these data we cannot distinguish between no certification and certification out of subject area) or hold a private school certification do less well than students whose teachers hold a standard, probationary, or emergency certification in math. Roughly speaking, having a teacher with a standard certification in mathematics rather than a private school certification or a certification out of subject results in at least a 1.3 point increase in the mathematics test. This is equivalent to about 10% of the standard deviation on the 12th grade test, a little more than the impact of having a teacher with a BA and MA in mathematics. Though the effects are not as strong in magnitude or statistical significance, the pattern of results in science mimics that in mathematics. Teachers who hold private school certification or are not certified in their subject area have a negative (though not statistically significant) impact on science test scores (p. 139).

The significant effect of teachers' certification on student achievement, especially in mathematics, is an important finding for a number of reasons. First, the finding is robust across estimates: Students of certified teachers in mathematics do substantially better than those of uncertified teachers in every analysis. (The somewhat weaker but still positive findings in science may be partly a function of idiosyncrasies of science certification, discussed further below). In science, students of probationary teachers—beginning teachers who have completed all of their training and are fully qualified to teach while they complete a two to three year probationary period—do about the same as students of more experienced teachers who hold standard certification; however, in mathematics, students of probationary teacher do even better. Since teacher experience and degrees are already controlled in the estimates, these outcomes may suggest improvements in beginning teachers' expertise stimulated by new standards for certification enacted in many states since the 1980s.

In this sample, students of teachers with temporary or emergency certification also do better than students whose teachers are uncertified. As we discuss in the next section, given the characteristics of this sample and the structure of state systems for granting such licenses, which are usually valid for one or, rarely, two years while standard certification requirements are completed, this finding also supports the value of certification. These teachers, most of whom are experienced and have education training, appear largely to be teachers from out-of-state who are in the transition period to securing their new state license, experienced teachers teaching out of their main field, or new entrants who are close to completing the state's certification requirements. (Often this means finishing a state-required course or passing a state test.) Below we describe this sample of teachers and their qualifications, along with state guidelines for the licenses they hold.

Second, the regression estimates include a number of other variables that are highly correlated with certification status (see Tables A1 and A2 in the appendix). In particular, bachelors' and masters' degree fields are highly correlated with each other and with certification status. Teaching experience is also highly correlated with certification status. The fact that certification status is found to be a significant predictor after these effects are partialled out underscores the strength of the relationship. In addition, the fact that certification status has a stronger influence on student achievement than possession of a subject matter degree in the field (which shows a positive but non-significant influence on student achievement in mathematics and a negative influence in science), suggests that the process of preparation it reflects may add value to teachers' subject matter competence and may add important information to judgments about teachers' qualifications beyond what might be learned from degree status alone. This finding reinforces those of other studies that have found stronger influences on teachers' demonstrated skills and effectiveness associated with the amount of education training they have than with measures of their subject matter preparation alone (Ashton & Crocker, 1986, 1987; Darling-Hammond, 2000; Druva & Anderson, 1983; Evertson, Hawley, & Zlotnick, 1985; Ferguson & Womack, 1993; Guyton & Farokhi, 1987; Monk, 1994).

Goldhaber and Brewer find some further support for the notion that strengthening of certification requirements, like the testing efforts that many states have undertaken since the 1980s, may have a positive effect on teachers' competence. They tested

interaction effects on state licensure testing policies and licensure status for new (probationary) teachers on student achievement and found modest relationships:

> One might think that higher certification requirements translate into higher quality teachers, which implies that states that have these requirements should have teachers whose students perform better. In fact there is some evidence (the coefficient is significant at the 10% level) in science that the students of teachers with probationary certification in states with admissions tests outperform those of teachers with similar licenses in states without that requirement. In math there is a similar positive impact, but the coefficient is not statistically significant. There is also some evidence (at the 5% level) in science that states with a pre-licensure test have teachers with standard certification who outperform those in states without this requirement (p. 140).

From a policy perspective, the study's findings suggest that, despite the widely acknowledged imperfections in state licensure systems, state policy makers may be doing something useful in the way they fashion requirements for knowledge of subject matter content, teaching skills, and clinical training in their certification guidelines. Recent efforts to strengthen these requirements may have contributed to improvements in teachers' preparation.

Despite the strength of these findings, Goldhaber and Brewer emphasize the nonsignificant coefficients associated with the small sample of teachers (34 in math and 24 in science) who hold "emergency" certification (actually defined in the NELS survey questionnaire as including "temporary" or "emergency" certification). They assert:

> One particularly important finding is that the students of teachers with emergency certification in mathematics do no worse than students who have teachers with standard certification. The results with regard to emergency certification are striking because they strongly contrast with the conventional wisdom (put forth by the NCTAF and others) that good teachers only come through conventional routes.

Later they argue that this finding should "cast doubt on the claims of the educational establishment that standard certification should be required of all teachers" (p. 141). The authors' treatment of this finding with so little scientific scrutiny and so much policy confidence is striking. Generally, social scientists are especially cautious when interpreting findings that derive from small samples vulnerable to large sampling error, particularly when they are examined in correlational analyses that include many variables collinear with the variables of interest. (The complete estimates include more than 30 variables, a number of which—type and level of teachers' degree, experience, and student demographics like poverty and school track—are highly correlated with certification status.)

Goldhaber and Brewer speculate about the meaning of this finding, suggesting that

> [O]ne explanation . . . is that teachers with emergency credentials have been more carefully screened by school districts for ability or content knowledge than those with standard certification. If this is the case, our findings may reflect an individual teacher selection effect. We cannot determine whether these individuals might not have been even more effective had they received conventional training. However, it is not clear that the individuals who do enter the profession with emergency credentials would have become teachers had they been required to enter the profession through conventional routes. (p. 139)

This interpretation suggests that these emergency certified teachers may have entered through alternative certification routes and may have stronger content backgrounds and less education training than those with standard certification.

In fact, a review of the data shows that this speculation is clearly not true for most of this sub-sample. Because temporary and emergency licenses are valid for only one or two years (and alternative certificates typically convert to standard certificates within two years), Goldhaber and Brewer's characterization of the sample could pertain only to teachers with 1 or 2 years of experience. In most states, temporary or emergency licenses are granted to experienced applicants who are already licensed in another field or state and who have only a few requirements left to fulfill. As we illustrate below, this sample is largely made up of experienced teachers, rather than novices who might be entering on an alternative credential. It is likely that these teachers hold an emergency certificate to authorize them to teach "out-of-field" temporarily or while they are completing requirements for a standard license. A large number are new to their schools although not new to teaching. Given the uses of many states' temporary certificates for out-of-state licensed entrants, it is likely that some of these are out-of-state entrants. Most have degrees and coursework back-

ground that would be part of a preparation program at the undergraduate or graduate level.

An understanding of states' certification regulations and careful scrutiny of the data suggest that for this tiny sub-sample of temporary/emergency certified teachers, while a small number may be new teachers who could have been non-traditionally prepared, most are experienced teachers who appear to be teaching "out-of-field" or are in transition between fields or locations.

Clarification of Licensing Categories

Goldhaber and Brewer suggest that the emergency certified teachers in this sample have entered teaching through non-conventional routes and may have stronger content backgrounds and less education training than those with standard certification. In fact, each fully certified teacher in this sample is much more likely to have a bachelors degree in the field he or she teaches than is an emergency certified teacher. The authors' suggestion shows a limited understanding of the ways in which states define and grant temporary and emergency licenses.

The National Association of State Directors of Teacher Education and Certification (NASDTEC) has worked with states to develop greater commonality in licensing categories and to create reciprocity arrangements that now apply across most states. The NASDTEC description of state licensing systems, published annually, clarifies the kinds of teaching credentials that must be obtained and held by those possessing temporary, emergency, and provisional certificates—terms used for the short-term certificates granted by different states. The NASDTEC manual makes it clear that most temporary and emergency credentials are valid for one or, at most, two years and are nonrenewable. Furthermore, these credentials are frequently developed to authorize individuals to teach when they have entered with credentials from other states or are in the process of completing minor coursework and test requirements.

For example, in California, the "one-year nonrenewable" certificate is "offered to out-of-state applicants who successfully completed approved teacher education programs before they pass the California Basic Education Skills Test." A "two-year preliminary credential" is "offered to fully prepared out-of-state applicants who have passed the California Basic Educational Skills Test while completing other exams and coursework required in California" (e.g., the required course in the U.S. Constitution). California's alternative credential, the district intern certificate, is "valid for two years while interning under supervision of master teacher and taking coursework. When successfully completed, a professional clear credential is issued" (NASDTEC, 1998, pp. A15-16).

In New Jersey and Texas (the two other states with the largest numbers of teachers alternatively certified through non-university programs), the alternative credential is good for one year during the training process, after which successful candidates receive a full standard license (NASDTEC, 1998, pp.A-93, A-135). Colorado's requirement is typical of other states with such licenses who typically rely on university-based masters degree or credential programs. There the "alternative teacher license" is valid for 1 year and is nonrenewable; it is available to candidates who have "completed a BA, state tests in basic skills, liberal arts and sciences and the content area while they complete an approved alternative (post-baccalaureate) teacher program. Upon completion, candidates are eligible for the provisional teacher license granted to new fully prepared teachers and to out-of-state entrants." (NASDTEC, 1998, p. A-21).

Illinois and Wisconsin are typical of the more restrictive approach taken by Midwestern states. Illinois does not list an emergency certificate among its NASDTEC categories. Its "provisional" nonstandard certificate, valid for two years and nonrenewable, is granted to candidates who

> [m]eet the requirements for a regular teaching, school service, or administrative certificate in another state; bachelor's degree or higher from a recognized institution; and the academic and professional courses offered as a basis for the certificate must be courses approved by the State Board of Education in consultation with the State Teacher Certification Board. The provisional certificate is valid for an initial nine months during which the basic skills and subject matter knowledge tests must be taken and passed (NASDTEC, 1998, p. A-46).

In Wisconsin the special emergency license, valid for one year or less, is granted to those with "a teaching license in another category, bachelor's degree, and request by the school district due to a shortage of licensed applicants." The two-year license is issued "to out-of-state approved program graduates who have minor course/credit deficiencies (for example, the course in the teaching of read-

ing or in special education)" (NASDTEC, 1998, A-152). Some states, for example, Nebraska, also offer such provisional licenses to for persons reentering the profession who do not have recent teaching experience but otherwise meet all requirements (NASDTEC, 1998, A-86). Washington, like many other states, issues an emergency certificate "at the request of an employing school district to a person who has substantially completed the requirements for the initial certificate and who can be expected to complete the requirements within the school year in which the certificate is issued" (NASDTEC, 1998, A-147).

In many states, holders of temporary and emergency credentials are primarily individuals who are fully qualified to teach but are entering from another state or are re-entering teaching after a hiatus, who are fully qualified in another field and are teaching out-of-field (while becoming qualified or simply taking over classes for a year), or who are mostly qualified in the field in question but need to complete a test or a course. As teacher testing has increased, some states have had a substantial number of individuals enter teaching following teacher preparation who have not satisfied their testing requirements when they start teaching, as well as many who enter from out-of-state and no longer received automatic reciprocity without passing a test. At the same time, in some states, such credential-holders may lack a substantial amount of subject matter or education training. Thus, in the abstract, especially in a national sample, it is difficult to generalize about the pathways such credential holders have pursued.

Finally, both "alternate routes" and "traditional routes" operate under widely divergent standards. For example, the amount of professional education beyond a liberal arts degree required of alternate route candidates varied from only 9 hours in Virginia to 45 credit hours required for a full master's degree or its equivalent in Alabama or Maryland in 1990 when the NELS data were collected (Feistritzer, 1990). Most states' alternate routes in the early 1990s required completion of a concentrated post-baccalaureate credential program including supervised student teaching prior to assuming a position as independent teacher of record. A few states, like New Jersey and Texas, allowed districts or the state itself to offer a route that offered a few weeks of training before teachers could take on a class and required a total of as little as 200 seat hours of training.

Regular certification standards also vary widely across states. Some states, such as New York and Connecticut, require a master's degree on top of a strong subject matter degree for full professional (standard) certification, and these requirements generally incorporate 40 credits of professional education coursework and a lengthy supervised practicum in addition to subject matter preparation. Meanwhile, others, like Louisiana, do not even require a minor in the field to be taught and specify few education coursework or clinical training demands. During the 1980s, New Jersey, Virginia, and Texas placed a ceiling on professional education coursework of no more than 18 credits at the undergraduate level, without requiring a master's degree or intensive internship experience to compensate for the reductions in professional preparation. Furthermore, states differ substantially in entry requirements to teacher education. Thus, alternate route candidates in 'high standards' states are subject to higher selection standards and receive a substantially more rigorous professional preparation than either "regular" or "alternative" certification candidates in 'low standards' states. This variability means that it is difficult to generalize about teachers' qualifications in a national sample based on certification status alone.

The Teachers in Question

Goldhaber and Brewer's own summary data show little difference between the degree qualifications of their teachers holding standard and temporary/emergency certification. In their Table 2, the proportions of teachers in each category holding a BA in the subject major, BA in education, and MA major in subject are similar. (See Table 1 below.) One difference is that the share of math teachers with BA majors in mathematics is noticeably larger for those with standard certification than with temporary/emergency certification (75% versus 57%), a difference that contradicts Goldhaber and Brewer's speculation about the greater content preparation of emergency certified teachers. The proportions of temporary/emergency certified teachers with masters degrees in education are smaller than those for standard certified teachers. This could be due in part to a difference in pathways to teaching, but is also undoubtedly due to a difference in average teacher experience levels, which are highly correlated with masters degrees, since many teachers earn these over time to advance on the salary schedule.

TABLE 1
Characteristics of Math and Science Teachers in Goldhaber and Brewer's Sample

Teacher education	Standard certification in math (n = 1,695)	Temporary or emergency certification in math (n = 34)	Standard certification in science (n = 1,106)	Temporary or emergency certification in science (n = 24)
BA major in subject	.75	.57	.49	.53
BA major in education	.29	.24	.37	.32
MA major in subject[a]	.43	.57	.49	.43
MA major in education	.45	.29	.37	.29
Yrs. of secondary teaching experience	17.9	6.1	17.2	7.2

[a] There is an anomaly in Goldhaber and Brewer's reported data about masters degrees, since the total share of teachers with masters degrees for the emergency-certified samples (.21 in math and .37 in science) appears to be smaller than the numbers with masters degrees in either the subject area or in education.

To understand the backgrounds of these teachers more fully, we examined the NELS data for all temporary/emergency certified science and math teachers associated with students who had both 10th and 12th grade test data. Our samples are somewhat larger than those recorded in Goldhaber and Brewer's table; we assume this is because they deleted individuals from the analysis who had missing data on any of the teacher or student variables of interest. (See Table 2.)

These data indicate, first, that most of the teachers in both mathematics and science are likely to have been prepared in education through one of 3 currently common routes:

- an education bachelor's degree, which has been less common since the early 1980s when several states eliminated the education major and many added as a credentialing requirement that candidates must complete a major in the field to be taught;
- a degree in the field to be taught plus a minor in education (this is the norm for secondary teachers in many states); or
- a degree or credential in education taken at the post-baccalaureate level, which has accounted for more than 15% of teachers prepared nationally since 1990.

There are also a few teachers in this sample with degrees in a math or science field other than the one for which their students were sampled who also hold a minor in education. Just over 60% of the teachers in each sample have non-overlapping education degrees.[1] This estimate of the number of teachers with education preparation is biased downwards because it does not include those who receive a credential through a non-degree granting program. This constitutes a large number of those who prepare for teaching at the post-baccalaureate level, usually in one-year credential programs (this includes most teachers in California, for example), or at the bachelors level in institutions that grant a major and a credential instead of an education minor.

Second, about half of the sample has a strong content background in the field in which they hold a temporary credential. Forty-eight percent of the math teachers hold BA majors or graduate degrees in mathematics. Forty-nine percent of the science teachers hold BA majors or graduate degrees in science. About 40% of each group reports having taken more than 8 undergraduate plus graduate courses in the field they teach. (A major usually requires around 10 courses). About half of the teachers appear to be teaching outside of their main field of preparation, although some of these teachers have some content background in math or science. About 18% of temporary credential holders in math were prepared in science, and about 36% were prepared in other non-math or science fields. Among the temporary credential holders in science, about 10% were prepared in math and about 33% in other fields.[2]

About 45% of both the math and science teachers reported that they taught a new subject in the year of the survey, an explanation compatible with an interpretation that they might be teaching in a new field while completing the requirements needed to be credentialed in that field or simply meeting a school need for course coverage. (This common source of out-of-field assignment is detailed in Ingersoll, 1999.) About one-fourth of the math teach-

TABLE 2
Characteristics of Mathematics and Science Teachers who Hold Temporary or Emergency Certification

Teacher characteristics (%)	Math teachers with temporary or emergency certification (%) (n = 73)	Science teachers with temporary or emergency certification (%) (n = 49)
Education background		
BA major in education	21.9	28.6
BA or MA in field taught plus minor in education	21.9	20.4
BA or MA in other math/science field plus minor in education	5.5	6.1
Masters or ed. specialist degree in education[a]	24.6	18.3
Subject-matter background		
BA major in mathematics	43.8	10.2
BA major or graduate degree in mathematics	47.9	10.2
BA major in science	17.8	44.9
BA major or graduate degree in science	17.8	49.0
> 8 undergrad. + grad. courses in field taught	40.0	45.0
BA and MA in non-math or science fields	35.9	32.6
Teaching experience		
Previously taught at elementary level	12.3	16.3
Yrs. of secondary teaching experience: 3 or less	31.5	34.7
Yrs. of experience in this school: 3 or less	42.5	53.1
Subjects taught		
Taught a new subject this year	44.9	45.2
Also teach another subject: math or science	23.3	24.5
Also teach a subject other than math or science[b]	34.1	18.3

[a] 13.7% of math teachers hold two degrees in education; 8.2% of science teachers hold two degrees in education.
[b] Among emergency certified math teachers, 9.6% teach vocational education, 5.5% teach in the humanities, 4.1% teach computer science, and 15.1% teach in a variety of other fields. Among emergency certified science teachers, 4.1% teach physical education, 4.1% teach special education, 4.0% teach in the humanities, and 6.1% teach in a variety of other fields.

ers were teaching science as well as math, and a similar share of science teachers were teaching math as well as science. Additionally, about 34% of math teachers and 18% of science teachers were teaching other non-math or science subjects, which may in fact have been their primary subjects. About 10% of emergency-certified math teachers taught vocational education, the most frequently listed additional subject area. About 4% of the science teachers were also teaching physical education and about 4% were teaching special education, the two largest additional subject areas reported.

Unfortunately, the survey did not allow a match between science fields in which individuals were prepared and the specific science subjects they taught. Science is a particularly knotty field of certification, since some states certify teachers separately for each science area (e.g. physics, chemistry, biology, earth science) while others accept broader certifications. Among states with the most tightly configured and rigorously enforced standards, a teacher may be considered out-of-field if he or she is certified in chemistry but also teaches physics or biology without a separate credential or endorsement, and may need to apply for a temporary credential in order to do so. In other states, such a teacher might be covered by a broader science certification and would not be considered out-of-field. Hence, the classifications of teachers and their qualifications for the fields they teach become blurred in national surveys of this kind that cannot make the fine-grained distinctions in categories that pertain in different states.

Finally, it turns out to be true, as we hypothesized earlier, that less experienced teachers are more likely to fit the profile of teachers who have entered with subject matter backgrounds but without education degrees, characterized by Goldhaber and Brewer as nonconventional or alternative entrants. Because of the way the survey questions were

TABLE 3
Educational Backgrounds of Math and Science Teachers with Temporary/Emergency Certification, by Experience Level

	Math teachers		Science teachers	
Education background	0–3 yrs. (n = 22)	4+ yrs. (n = 51)	0–3 yrs. (n = 16)	4+ yrs. (n = 33)
BA major or minor in education	27.3	45.1	37.6	36.4
MA or specialist degree in education	0	35.3	12.5	21.2
BA or MA in math	54.5	45.1	6.3	12.1
BA or MA in science	22.7	15.7	75.0	36.4

asked, we cannot account for those who may have other credentials (i.e., teaching credentials that were awarded alongside or in addition to a bachelors or masters degree outside of the field and state in which the teacher currently teach), but it is possible to confirm the spirit of Goldhaber and Brewer's speculation about this subset of the sample.

As Table 3 illustrates, both math and science teachers with 3 or fewer years of experience are more likely to hold degrees in the content area they are teaching. This is particularly true in science. This could be a function of increasingly stringent certification requirements regarding content training (for both standard and temporary licenses) or differences in recruitment pathways for these groups of teachers, or both. In addition, inexperienced math and science teachers are less likely to hold post-baccalaureate degrees in education. Math teachers with fewer years of experience are also noticeably less likely to hold BA majors or minors in education. Therefore, it is plausible that some of these newer teachers were entering with the stronger content training and weaker education training Goldhaber and Brewer attribute to "alternative certification." (In fact, the actual content of alternative routes differs across states, with some requiring the same amount of education and content training as traditional routes and others requiring less.)

Goldhaber and Brewer's additional speculation that these non-conventional recruits may produce higher student achievement, however, is not supported by an analysis of student achievement for these different groups of teachers. Using an analysis of variance, we examined the 12th grade student test scores, controlling for 10th grade scores, of students who had teachers with 4 or more years of experience (the more conventionally prepared group) vs. those who had teachers with 3 or fewer years of experience (the group that appears to be less conventionally trained).[3] As Tables 4 and 5 illustrate, students taught by the more experienced and more conventionally prepared group had significantly higher achievement than those taught by the less experienced, less conventionally qualified group ($p < .05$ in mathematics and $p < .001$ in science).

Since education backgrounds and experience levels are correlated, we also examined the relationship between teachers' education degrees and student achievement, with experience and teachers' disciplinary degrees as covariates. (See Tables 6 and 7.) The "education degrees" variable is a rough proxy for education background based on education major, minor, masters, or education specialist degree.[4] In these analyses, we found that education degrees absorb a noticeable share of the variance previously explained by teacher experience.

TABLE 4
Relationship Between Teacher Experience and Student Achievement, Mathematics (ANOVA)

Mathematics, 12th-grade scores	*SS*	*df*	*MS*	*F*
Covariate: 10th-grade scores	3,892.7	1	3,892.7	60.6**
Main effect: 4+ yrs. experience	267.8	1	267.8	4.2*
Explained	4,776.5	2	2,388.3	37.2**
Residual	7,970.9	124	64.3	
Total	12,747.5	126	101.2	

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

TABLE 5
Relationship Between Teacher Experience and Student Achievement, Science (ANOVA)

Science, 12th-grade scores	*SS*	*df*	*MS*	*F*
Covariate: 10th-grade scores	4,234.0	1	4,234.0	81.3*
Main effect: 4+ yrs. experience	672.8	1	672.8	12.9*
Explained	4,264.6	2	2,312.3	44.4*
Residual	4,949.2	95	52.1	
Total	9,573.8	97	98.7	

* $p < .001$.

Although neither is statistically significant at the 5% level, both education degrees and disciplinary degrees exert a positive influence on student achievement. The effect size, however, is several times larger for education degrees.

This analysis cannot ascertain whether or not conventionally prepared teachers (i.e., those with education training) are more effective than non-conventional entrants. As noted above, we lack important information about these teachers' education and content backgrounds. However, these data do not support Goldhaber and Brewer's assertions that less conventionally trained teachers are likely to be more effective than those with more complete or more standard preparation.

It is not possible to know whether the findings about student outcomes for this group of teachers with temporary certification and those with standard certification would hold up with a larger sample or under the different labor market conditions that pertain today. It is possible to ascertain, however, that the educational training of this group does not match Goldhaber and Brewer's assumptions. Most of this sample of temporary/emergency certified teachers has qualifications quite similar to the sample of teachers with standard certification. Most have qualifications in education. At least half appear to have solid content training in the field they teach. In addition, a noticeable proportion of the sample (about 25%) appear to be math teachers who are teaching science or vice-versa. Some of these have at least a minor in the other field. These groups of teachers, who appear to have substantially comparable credentials to those with standard certification, are probably out-of-state, re-entering, cross-assigned, or otherwise nearly certified teachers who are completing minor requirements needed for a standard certificate.

The sample also includes a noticeable proportion of teachers (about 30%) who appear to be teaching well outside their fields, in other words, non-math or science teachers who are teaching math or science part of the time. One would expect that these teachers are more likely to be assigned out-of-field due to pressing school-level needs rather than their own training. Some may be teaching on emergency credentials without being close to having certification in this field and without an intention of continuing to teach in the field.

Finally, we found that the third of the sample that are teachers with 3 or fewer years of experience partly fits the profile suggested by Goldhaber and Brewer; that is, they are more likely to have degrees in the content field and less likely to have degrees

TABLE 6
Relationship Between Teacher Education, Experience, and Student Achievement in Mathematics (ANOVA)

Mathematics, 12th-grade scores	*SS*	*df*	*MS*	*F*
Covariates	4,853.6	3	1,617.9	25.6*
10th-grade scores	4,498.1	1	4,498.1	70.9*
Years of teaching experience	229.2	1	229.2	3.6
Math BA or MA	28.7	1	28.7	0.5
Main effect: Education degree	137.8	1	137.8	2.2
Explained	4,863.6	4	1,215.9	18.2*
Residual	8,055.6	127	63.4	
Total	12,919.1	131	98.6	

*$p < .001$.

TABLE 7
Relationship Between Teacher Experience and Student Achievement, Science (ANOVA)

Science, 12th-grade scores	*SS*	*df*	*MS*	*F*
Covariates	6,313.8	3	2,104.6	28.0*
10th-grade scores	5,689.0	1	5,689.0	75.8*
Years of teaching experience	153.8	1	153.8	2.1
Science BA or MA	0.8	1	0.8	0.0
Main effect: Education degree	18.9	1	18.9	0.3
Explained	6,413.8	4	1,603.4	21.4*
Residual	15,157.4	202	75.0	
Total	21,571.2	206	104.7	

*$p < .001$.

in education. These teachers could include some "non-traditional" recruits who entered on alternative certificates or who resemble those entering on such certificates now that they are more common than they were in 1990. These teachers are not associated with higher achievement for their students as Goldhaber and Brewer speculated. In an analysis of variance that controlled for 10th grade student scores, students of teachers in the less experienced group had significantly lower achievement in math and science in 12th grade than those of the more experienced, more conventionally trained teachers. When experience was controlled, both education degrees and levels of experience had positive but smaller influences on student achievement.

Given the fact that temporary credentialing requirements exist primarily to ensure that teachers work toward and meet standard certification requirements, that fully certified teachers produce stronger achievement in students, and that teachers' efforts to become more completely prepared are associated with better outcomes for their students, it is difficult to sustain Goldhaber and Brewer's recommendation that states should abandon their certification systems.

Other Research on Teacher Education and Certification

Goldhaber and Brewer claim that there is little research on the value of teacher certification or conventional education preparation. They cite one study that showed a strong positive effect of teacher certification on student achievement in mathematics (Hawk, Coble, & Swanson, 1985) and one that did not (Rudner, 1999). The first of these was a carefully controlled matched comparison group study that matched teachers by experience level and school and used pre- and post-tests of student learning at the beginning and end of the school year in the specific curriculum taught. It found that students of teachers who were certified in mathematics performed significantly better in both general mathematics ($p < .05$) and algebra ($p < .001$) than those who were taught by teachers uncertified in mathematics.

The second is actually not a study of teacher certification but a report of the demographic characteristics and test scores of a non-representative group of home schooled students who happened to have taken the testing services offered by Bob Jones University. This group of students was substantially whiter, more affluent, and had more highly educated parents than the national average. As might be expected, they also had higher test scores. In the course of the analysis, the author examined whether students who had a parent who held state certification achieved at higher levels than those who did not; he found no correlation between parents' certification status and student achievement. This study did not include any controls or pre- and post-measures of learning. It was not designed to test the effects of certification on achievement and did not employ any of the methodological strategies it would need to have used to do so.

In arguing for the importance of subject matter background for teaching, Goldhaber and Brewer cite Monk's (1994) finding from the Longitudinal Study of American Youth (LSAY) that subject matter courses appear to be positively, although not always significantly, related to student achievement in mathematics and science. However, they fail to report that the study found that teachers' coursework in education also contributed positively to student achievement, and these effects were often larger and more significant than the effects of

additional subject matter coursework. Nor do they note that the study found a curvilinear relationship between content coursework and student achievement gains; that is, beyond a threshold level (e.g., about 5 courses in mathematics), additional content courses for teachers did not improve their students' achievement. In contrast with Goldhaber and Brewer's conclusions, Monk concluded from his study that "a good grasp of one's subject area is a necessary but not a sufficient condition for effective teaching" (142).

Goldhaber and Brewer mention only one of several studies that have found positive school- or district-level effects on student achievement of teacher certification status and teachers' scores on certification tests that measure knowledge of teaching as well as subject matter (Ferguson, 1991; Fetler, 1999; Los Angeles County Office of Education, 1999; Strauss & Sawyer, 1986). They also do not mention other studies that find that teachers' backgrounds in education as well as in content influence their effectiveness with students. In a result similar to Monk's, Begle's (1979) review of findings from the National Longitudinal Study of Mathematical Abilities noted that the number of credits a teacher had taken in mathematics methods courses was a stronger correlate of student performance than was the number of credits in mathematics courses or than was degree status. Also like Monk, Begle and Geeslin (1972) found in a review of mathematics teaching that the absolute number of course credits in mathematics was not linearly related to teacher performance.

A review of research on science education incorporating the results of more than 65 studies found consistently positive relationships between students' achievement in science and their teachers' backgrounds in both education courses and science courses (Druva & Anderson, 1983). In a more in-depth analysis of how teachers' backgrounds effects their science teaching methods and outcomes, Perkes (1967-68) found that teachers' coursework credits in science were not significantly related to student learning, but that coursework in science education was significantly related to students' achievement on tasks requiring problem solving and applications of science knowledge. Teachers with greater training in science teaching were more likely to use laboratory techniques and discussions and to emphasize conceptual applications of ideas, whereas those with less education training placed more emphasis on memorization.

In a study of more than 200 graduates of a single teacher education program, Ferguson and Womack (1993) examined the influences on 13 dimensions of teaching performance of education and subject matter coursework, NTE subject matter test scores, and GPA in the student's major. They found that the amount of education coursework completed by teachers explained more than four times the variance in teacher performance (16.5 percent) than did measures of content knowledge (NTE scores and GPA in the major), which explained less than 4 percent. In a similar study that compared relative influences of different kinds of knowledge on 12 dimensions of teacher performance for more than 270 teachers, Guyton and Farokhi (1987) found consistent strong, positive relationships between teacher education coursework performance and teacher performance in the classroom as measured through a standardized observation instrument, whereas relationships between classroom performance and subject matter test scores were positive but insignificant, and relationships between classroom performance and basic skill scores were almost nonexistent.

Another program-based study by Denton and Lacina (1984) found positive relationships between the extent of teachers' professional education coursework and their teaching performance, including their students' achievement. Influences of education preparation on teachers' ratings and student achievement have also been found for teachers of vocational education (Erekson & Barr, 1985), teachers of reading and elementary education (Hice, 1970; LuPone, 1961; McNeil, 1974), early childhood teachers (Roupp, Travers, Glantz, & Coelen, 1979), and teachers of gifted students (Hansen, 1988).

Other studies point out the differences in the perceptions and practices of teachers with differing amounts and kinds of preparation. A number of studies suggest that the typical problems of beginning teachers are lessened for those who have had more preparation prior to entry (Adams, Hutchinson, & Martray, 1980; Glassberg, 1980; Taylor & Dale, 1971). Teachers who are well prepared appear to be better able to use teaching strategies that respond to students' needs and learning styles and that encourage higher order learning (Perkes, 1967-68; Hansen, 1988; Skipper & Quantz, 1987). Goldhaber and Brewer did not include studies of teachers recruited through short-term alternate routes that have found that such recruits tend to have greater

difficulties planning curriculum, teaching, managing the classroom, and diagnosing students' learning needs (Lenk, 1989; Feiman-Nemser & Parker, 1990; Gomez & Grobe, 1990; Grady, Collins, & Grady, 1991; Grossman, 1989; Mitchell, 1987), and that they tend to be much less satisfied with their training (Darling-Hammond, Hudson, & Kirby, 1989; Jelmberg, 1995).

A number of studies have found that principals, supervisors, and colleagues tend to rate recruits from such truncated programs less highly on their instructional skills (Jelmberg, 1995; Lenk, 1989; Feiman-Nemser & Parker, 1990; Gomez & Grobe, 1990; Mitchell, 1987; Texas Education Agency, 1993), and the recruits tend to leave teaching at higher-than-average rates (Darling-Hammond, Hudson, & Kirby, 1989; Lutz & Hutton, 1989; Stoddart, 1992; Shen, 1997). The fact that recruits from these short-term programs are much more likely to be teaching low-income and minority children in disadvantaged schools (Shen, 1997) is a critical aspect of the policy issue unaddressed by Goldhaber and Brewer.

In their claims about alternative certification, which they characterize as emphasizing subject matter background rather than education training, the authors fail to distinguish between alternative programs which provide training that meets the same standards as traditional programs but package it in different ways (e.g., intensive post-baccalaureate programs that provide education coursework and intensively supervised clinical training in about a year) and those that meet a lower set of standards (e.g., quick summer programs that offer a few weeks of induction and that place teachers in classrooms with little supervision or mentoring to learn through trial and error). Some of the latter require reduced levels of subject matter and education coursework and provide waivers from specific state licensing examinations as well.

The fact that there is substantial variability among both "traditional" programs and "alternative" programs is a critical issue. As one review of nontraditional program models noted, there are major differences between the design and outcomes of *alternate routes* to certification that maintain standards but concentrate coursework and clinical training and those of *alternative certification* approaches that reduce requirements and leave both training and licensing responsibilities to local districts, especially in hard-pressed cities that often can ill afford the costs of mentoring and supervision (Darling-Hammond, 1992). A study by RAND of nontraditional pathways found that the graduates of the longer and more intensively supervised alternate routes felt better prepared and were much more likely to report they would stay in teaching than those who had completed short-term alternatives (Darling-Hammond, Hudson, & Kirby, 1989, 106).

The National Commission on Teaching and America's Future (NCTAF) (1996) raised these issues. Goldhaber and Brewer portray the Commission as the purveyor of "the conventional wisdom . . . that good teachers only come through conventional routes." However, the Commission strongly critiqued the flaws of many traditional teacher education programs and roundly criticized many states' licensing systems, recommending an overhaul of both to encourage accountability against performance standards (pp. 27–32). The Commission report pointed out that new designs for teacher education programs appear to be more effective than the design of most traditional undergraduate programs, citing a number of recent studies which found that graduates of extended (typically 5-year) programs are not only more satisfied with their preparation, but that they are viewed by their colleagues, principals, and cooperating teachers as better prepared, are as effective with students as much more experienced teachers, and are much more likely to enter and stay in teaching than their peers prepared in traditional 4-year programs (Andrew, 1990; Andrew & Schwab, 1995; Arch, 1989; Denton & Peters, 1988; Dyal, 1993; Shin, 1994).

NCTAF also recommended that states support high-quality alternative routes to recruit mid-career entrants into teaching, and gave several examples of alternatives that have collected outcome data to demonstrate their effects (pp. 92–94). Most of these share the feature of a year-long clinical training experience combined with intensive coursework—a feature that appears to contribute to the effectiveness of 5-year teacher education models as well. The Commission's report stated that

> high-quality alternative pathways into teaching have proved themselves to be effective in preparing nontraditional entrants—mid-career recruits and retirees from business and the military—to enter and succeed at teaching. The Commission endorses these programs. The most successful offer a streamlined, carefully constructed curriculum that integrates courses on learning theory, development, teaching methods, and subject matter knowledge with an intensively supervised internship prior to entry. Because they are tailored

> to the specific needs of recruits and are undertaken in partnership with nearby schools, they can concentrate preparation within a 9–12 month program and provide the additional mentoring that really prepares candidates to teach. (p. 53)

At the same time, the Commission raised concerns about low-quality alternative certification programs, noting that "programs offering a few weeks of summer training before new hires are thrown into the classroom . . . have proven to be even lower in quality than the programs they aim to replace" and citing a number of studies that found lower levels of effectiveness and retention for teachers trained in these programs (NCTAF, 1996, p. 53).

Ignoring this research, Goldhaber and Brewer state that "the few studies of alternative certification find that students of alternate-route teachers do at least as well as pupils of traditionally licensed teachers." For this conclusion, they cite only three articles, one of which presents no empirical data whatsoever. This last, an unpublished paper by Barnes, Salmon, and Wale (1989), asserts that two districts in Texas reportedly found equivalent outcomes for alternative and traditional program teachers. The paper does not present any empirical data on this assertion nor does it cite other studies, but it does include a table listing teacher education programs presumably included in whatever comparisons were done. This list includes one- and two-year university-based master's programs (which are called "alternative" in Texas because they are not undergraduate models) as well as district programs that generally offer only a few weeks of summer training before teachers are assigned to classrooms. Thus, the "alternative" group included programs providing extensive graduate level training of the sort that many states would call 'traditional" along with programs that provide little formal preparation prior to entry into teaching. Aside from the unanswered question of what analyses were done to support the article's assertion, the wide range of program models included as "alternative" precludes any inferences about the effects of preparation on teacher effectiveness.

A second study cited by Goldhaber and Brewer was a study of Houston's alternative certification program (Goebel, Romacher, & Sanchez, 1989), which found little evidence of teacher effects on student achievement and no evidence of differential student outcomes between differently certified groups of teachers. This study, however, did not include any controls to allow measurement of teacher effects. First, it evaluated only a cross-sectional sample of test scores without calculating gains or controlling for students' initial test scores; second, it did not match comparison teachers by years of experience. First-year traditionally trained teachers were compared to groups of much more experienced alternative certification recruits who had up to 7 years of experience. Had the study been done with appropriate student gain measures, one might have drawn the inference that traditionally prepared beginners were no different in effectiveness than alternatively prepared teachers with many more years of experience—an outcome different from the one Goldhaber and Brewer suggest.

Goldhaber and Brewer did not report on Gomez and Grobe's (1990) better designed study of the performance of alternate route candidates in Dallas, who, like those in Houston's intern program, receive a few weeks of summer training from the district before they assume full teaching responsibilities. This study used comparison groups of beginning teachers who were alternatively and traditionally prepared and controlled for initial student test scores in evaluating effects on achievement. The two groups of teachers had obtained equivalent scores on the Texas subject matter tests. The study found that, although alternatively prepared candidates were rated near the average on some aspects of teaching, they were rated lower on such factors as their knowledge of instructional techniques and instructional models. The performance of alternate route candidates was also much more uneven than that of trained teachers, with a much greater proportion of them—from 2 to 16 times as many—rated "poor" on each of the teaching factors evaluated. The strongest effects of this unevenness were seen in their students' achievement in language arts and writing, where the achievement gains of students of alternate route teachers, adjusted for initial student scores, were significantly lower than those of students of traditionally trained teachers on two separate test batteries.

The third study cited by Goldhaber and Brewer (Miller, McKenna, & McKenna, 1996) is a well designed study of what the study's authors call a "carefully constructed" university-based alternate route program for middle school teachers. Reflecting many of the characteristics of alternative routes cited by the National Commission on Teaching, this program offered 15 to 25 credit hours of coursework before interns entered classrooms where they were intensively supervised and assisted by both uni-

versity supervisors and school-based mentors while they completed additional coursework needed to meet full standard state certification requirements. These teachers were compared to a group of traditionally certified teachers matched for years of experience. The traditionally trained teachers in this study felt somewhat more confident in their practice and scored slightly higher on the two sub-scales of an observation instrument used by trained observers to rate their teaching. However, these differences were not significant, and there were no significant differences in the two groups' student achievement by the third year of practice. (The authors did not control for prior achievement levels of students; however, they stated that the initial differences in student achievement across groups were not significant.)

Because the design of this program was so different from many quick-entry alternative routes, Miller, McKenna, and McKenna note that their studies "provide no solace for those who believe that anyone with a bachelor's degree can be placed in a classroom and expect to be equally successful as those having completed traditional education programs. . . . The three studies reported here support carefully constructed AC programs with extensive mentoring components, post-graduation training, regular inservice classes, and ongoing university supervision" (p. 174).

Their findings are reminiscent of those of a state evaluation of the Los Angeles teacher trainee program which compared several different kinds of teaching recruits—university trained teachers without mentors, alternate route teachers with mentors, and one group of alternate route entrants who decided to enroll in regular university teacher education programs, rather than the short alternate route summer program, while still receiving state-funded mentor support. The group of university-prepared candidates who received a full complement of education coursework and intensive mentoring in their first year on the job far outscored any of the other recruits on every criterion of classroom effectiveness evaluated by trained observers, suggesting the cumulative power of adding adequate preservice preparation to intensive on-the-job supervision (Wright, McKibbon, & Walton, 1987, p. 124). Like the research cited above, these studies illustrate that the more carefully constructed their coursework and clinical supports for learning to teach, the more teachers are able to accomplish with their students in the classroom.

Beyond Labels: Sorting out the Effects of Preparation and Certification

Goldhaber and Brewer's article concludes that, "Although teacher certification is pervasive, there is little rigorous evidence that it is systematically related to student achievement" (p. 141). Although they found strong positive relationships between student achievement and full certification—and consistently negative relationships between the lack of teacher certification and student performance—they draw strong policy inferences from their finding that "mathematics and science students who have teachers with emergency credentials do no worse than students with standard teaching credentials, all else equal" (p. 141). Since their regressions have already accounted for education degrees and content degrees (which are the major components of certification in most states and which substantially define the differences between the fully prepared and underprepared teachers holding temporary or emergency credentials), the finding tells us little about what kinds of teacher preparation matter for student achievement. It reveals even less about whether certification requirements are valuable.

A responsible research and policy agenda that builds on the evidence currently available about teacher education and certification should aim to illuminate more fully the specific aspects of teachers' knowledge and skills that make a difference for student learning and the ways in which the features of different teacher education models—how they organize the acquisition of content and teaching knowledge and build knowledge about practice as it is applied—are related to different teaching outcomes. A companion agenda should aim to understand how different teacher certification strategies encourage or discourage the construction of programs that produce well prepared teachers who stay in the profession, and how state policies distribute well prepared teachers equitably to all children in the state, regardless of race and income.

With respect to the quality of teacher certification policies, important questions include how well they encapsulate in their requirements useful information about what matters for teacher practice and effectiveness in the classroom. This should include an assessment of the validity and value-added costs and benefits of testing requirements as well as educational requirements. As Levin (1980) notes, certification is a critically important exercise in the eco-

nomics of information that should be a target of continual improvement:

> [T]he facts that we expect the schools to provide benefits to society that go beyond the sum of those conferred upon individual students, that it is difficult for many students and their parents to judge certain aspects of teacher proficiency, and that teachers cannot be instantaneously dismissed, mean that somehow the state must be concerned about the quality of teaching. It cannot be left only to the individual judgments of students and their parents or the educational administrators who are vested with managing the schools in behalf of society. The purpose of certification of teachers and accreditation of the programs in which they received their training is to provide information on whether teachers possess the minimum proficiencies that are required from the teaching function. Because this is an exercise in the provision of information, it is important to review the criteria for setting out how one selects the information that is necessary to make a certification or accreditation decision. (p. 7)

The field would be well served by thoughtful, well designed and adequately nuanced studies of how different kinds of knowledge matter for teaching, how these can be acquired in various types of preparation programs, and how their acquisition can be represented by state certification policies that provide both useful leverage on training and good information for schools.

APPENDIX A

Weighted Correlation Coefficients: Mathematics Teacher Sample

	Yrs. teaching	Full cert.	Prob. cert.	Temp/ emer. cert.	Priv. cert.	No cert.	BA deg.	MA deg.	Doct. deg.	BA in math	BA in ed.	MA in math	MA in ed.
Years teaching	1.0	.29**	−.17**	−.13**	.03	−.23**	−.14**	.26**	.05*	.13**	−.05*	.07*	.02
Full certification		1.0	−.28**	−.41**	−.25**	−.79**	−.06**	.14**	−.05*	.25**	.01	−.01	.08*
Probationary cert.			1.0	−.01	−.01	−.03	.03	−.07**	−.01	.02	.04	−.04	.04
Temp./emergency cert.				1.0	−.01	−.04	−.04	−.06**	−.02	−.05*	.01	.05	−.05
Private certification					1.0	−.02	.04	.02	.28**	.02	−.05*	.10**	−.07*
No certification						1.0	.03	−.12**	−.02	−.30**	−.01	−.05	−.04
BA degree							1.0	−.32**	−.00	.02	.02	−.04	.06*
MA degree								1.0	.07**	.04	−.07**	−.04	−.01
Doctoral degree									1.0	.01	.01	−.01	.02
BA in math										1.0	−.19**	.26**	−.01
BA in education											1.0	−.06	.24**
MA in math												1.0	−.45**
MA in education													1.0

Note. Cramer's V statistic, which is used to examine relationships among dichotomous variables, has the same value as the Pearson r product–moment correlation, which is reported here. *$p < .01$. ** $p < .001$.

APPENDIX B

Weighted Correlation Coefficients: Science Teacher Sample

	Yrs. teaching	Full cert.	Prob. cert.	Temp/ emer. cert.	Priv. cert.	No cert.	BA deg.	MA deg.	Doct. deg.	BA in science	BA in ed.	MA in science	MA in ed.
Years teaching	1.0	.16**	−.22**	−.13**	−.07*	0.1	−.20**	.33**	−.01	.04	.02	.06	.03
Full certification		1.0	−.38**	−.39**	−.31**	−.73**	−.04	−.04	.02	.23**	.09**	.11**	.17**
Probationary cert.			1.0	−.02	−.02	−.04	−.03	−.04	−.02	−.03	−.04	−.07*	.04
Temp./emergency cert.				1.0	−.02	−.04	.03	−.05	.01	−.04	.02	−.03	−.00
Private certification					1.0	−.03	−.11**	.04	−.00	.03	−.06	.11**	−.07*
No certification						1.0	.11**	.08**	−.12	−.27**	−.07*	−.16**	−.18**
BA degree							1.0	−.21**	−.04	−.11**	−.05	−.18**	−.03
MA degree								1.0	−.04	.00	−.13**	−.16**	−.09*
Doctoral degree									1.0	.00	−.05	.08*	−.07
BA in science										1.0	−.29**	.36**	.00
BA in education											1.0	.02	.27**
MA in science												1.0	−.37**
MA in education													1.0

Note. Cramer's V statistic, which is used to examine relationships among dichotomous variables, has the same value as the Pearson r product–moment correlation, which is reported here. *$p < .01$. **$p < .001$.

Notes

[1] The calculation of numbers of teachers with non-overlapping degrees was done to eliminate double counts of teachers who may hold both a bachelor's and a masters' degree in education and could thus create an overestimate of the numbers prepared through degree programs. This estimate does not include those who receive a credential through a non-degree granting program, which comprises a large number of those who prepare to teach at the post-baccalaureate level, usually in one year credential programs, or at the bachelors level in institutions that grant a major and a credential and do not have an education minor.

[2] Unfortunately, the survey did not permit a complete evaluation of what these fields are. In each case, fewer than 10% specified degrees in the humanities, and the remainder were classified as "other BA."

[3] We chose this method because of the small size of the sample and the associated need to maximize degrees of freedom and to avoid the problems of covarying a large number of variables, many of which are collinear.

[4] This variable underestimates the number of prepared individuals since the survey does not include data on those who completed education requirements in a non-degree credential program.

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