

**Teacher Qualifications and Early Learning:
Effects of Certification Status, Degree, and Experience
on First-Grade Achievement**

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1. Introduction

Although many federal, state, and local education policies promote high-quality teaching to enhance student achievement, questions persist about what constitutes quality teaching. One piece of this puzzle involves identifying specific teacher characteristics that predict their effectiveness, particularly in terms of improved student achievement. This is a fundamental issue inherent to policy discussions about which qualities and qualifications to promote in aspiring teachers, whom to recruit and hire, what factors to base pay schedules on, and how to distribute teachers across different types of schools and classrooms to achieve equity and adequacy in educational outcomes.

A number of researchers have argued that teacher quality is a powerful predictor of student performance. Darling-Hammond (1996, 2000) concludes that the effects of well-prepared teachers on student achievement can outweigh student background factors including poverty, language background, and minority status. Further, she contends that measures of teacher quality are more strongly related to student achievement than other kinds of investments, including reduced class sizes, overall spending on education, and teacher salaries. Using a very different conception of teacher quality, Rivkin, Hanushek, and Kain (1998) arrive at the same conclusions regarding the importance of teacher quality.¹ They conclude from their analysis of 400,000 students in 3,000 schools that while school quality is an important determinant of student achievement, the most important predictor is teacher quality. Hanushek (1992) estimates that the difference between having a good teacher and having a bad teacher can exceed one

¹ Rivkin, Hanushek, and Kain (1998) identify teachers as a major determinant of student performance, but do not describe teacher quality in terms of specific qualifications and characteristics. They show strong, systematic

grade-level equivalent in annual achievement growth. Likewise, Sanders (1998) and Sanders and Rivers (1996) argue that the single most important factor affecting student achievement is teachers, and the effects of teachers on student achievement are both additive and cumulative. Further, they contend that lower achieving students are the most likely to benefit from increases in teacher effectiveness. Taken together, these multiple sources of evidence – however different in nature – all imply that quality teachers are a critical determinant of student achievement. In the current policy climate of standards-based reform, these findings make a strong case for gaining a better understanding of what really accounts for these effects.

Of particular interest is the impact of policy-relevant teacher qualifications such as degree level and certification. Existing research provides some direction regarding the impact of attributes of secondary school teachers. While quasi-experimental studies have been plagued historically by inconclusive findings regarding the impact of teacher degree at the secondary level (e.g., Summers & Wolfe 1975, 1977; Harnish, 1987; Ehrenberg & Brewer, 1994²; Monk, 1994), more recent studies that have attended to the subject area in which the advanced degree was earned have been relatively consistent in their findings of a positive effect of teacher degree on high school student achievement.

Goldhaber and Brewer (1997b, 2000) draw on nationally-representative data provided in NELS:88 to estimate the impact of teachers' holding masters degrees on high school students' mathematics achievement. These studies demonstrate the importance of the subject area in which the degree was awarded. The researchers found that student achievement gains in mathematics were positively associated with those assigned to teachers who earned their masters

differences in expected achievement gains related to different teachers using a variance-components model. In contrast, Darling-Hammond (1996, 2000) equates teacher quality with specific qualifications.

²This study did find that black students assigned to teachers holding a masters degree outperformed their counterparts assigned to teachers without the advanced degree.

degree in mathematics, controlling for student and teacher characteristics. No effect was evident in cases where the teachers had no advanced degree or where the degree was earned in a subject other than mathematics.

Goldhaber and Brewer (1998) further confirm the importance of subject-specific information about teacher preparation in their analysis of NELS:88 data to address questions about when to reward teacher degrees. Their findings suggest that general measures of teacher degree level are not related to high school student achievement in math, science, English, or history. However, in math and science, subject-specific degrees earned were found to have a positive impact on student test scores in those subjects. This was the case for both bachelor's as well as master's degrees. Further, teachers holding both a bachelor's and a master's degree in the subject area taught were the most effective.

Rowan, Chiang and Miller's (1997) analysis of the NELS:88 dataset further documents the importance of the subject matter of teachers' degrees. The model tested in this study includes a variable indicating whether the teacher had majored in mathematics in undergraduate and/or graduate school. While the researchers did not distinguish the level of the degree earned, the subject-specific degree variable was a positive predictor of 10th grade student achievement in all specifications of the model tested.

While fewer in number, studies of high school teacher certification parallel those of degree level, with positive effects limited to subject-specific credentials. Goldhaber and Brewer's (1997a) analysis of NELS:88 data revealed that students assigned to teachers who were certified in mathematics, or had earned a bachelor's or master's degree in mathematics had higher test scores than those assigned to teachers who lacked mathematics certification, controlling for other student and teacher characteristics. In contrast, they found that the

mathematics scores of students assigned to teachers with master's degrees or certification in subjects other than mathematics were no different than scores of students assigned to teachers with fewer qualifications, further underlining the importance of the subject-specific credentials.

While a clear picture is beginning to emerge regarding the effect of teacher degrees and certification at the high school level, the evidence at the elementary level remains mixed and inconclusive. The existing evidence of a positive effect of teacher degree level on elementary student achievement (Ferguson & Ladd, 1996) is overshadowed by the many studies that find either no discernable effect (Link & Ratledge, 1979; Murnane & Phillips, 1981), or even a negative effect (Murnane, 1975; Eberts & Stone, 1984; Kiesling, 1984; Rowan, Correnti, & Miller, 2002) of teachers' holding masters degrees on elementary student achievement. Strikingly little research has been conducted on the impact of teacher certification on the performance of elementary students, and that which has been studied reveals no discernable effect (Rowan, Correnti, & Miller, 2002).

In an effort to address this gap in the literature, this study draws on national data from the recent Early Childhood Longitudinal Study (ECLS) to analyze the relationship between elementary school teacher qualifications and student achievement. The analysis parallels the work of researchers who have studied the relationship between teacher qualifications and student achievement at the high school level (most notably, the work of Goldhaber & Brewer, 1997a, 1997b, 1998, 2000). In doing so, the study provides much needed empirical evidence about teacher quality at the elementary school level.

2. Empirical model

We use a traditional education production function model to examine the effects of first-grade teacher qualifications on children's first-grade achievement. We model the early learning of child i in a class taught by first-grade teacher j as a function of a vector of variables that tap education-related characteristics of individual children and their families (X_{ij}), a vector of variables that tap the characteristics of individual teachers (T_j), and a random error term:

$$Y_{ij} = \beta X_{ij} + \gamma T_j + \varepsilon_{ij}$$

The dependent variable (Y_{ij}) is a measure of achievement on one of three cognitive assessments administered to children at the end of the first grade. The vector of variables that tap the characteristics of children and their families (X_{ij}) includes gender, minority status, socioeconomic status, and prior achievement at the end of kindergarten. The vector of variables that tap the characteristics of teachers includes age, degree level, degree type, certification status, and years of first-grade experience. We focus on estimating the effects of γ associated with teacher qualifications (degree type, certification status, and experience) controlling for other teacher characteristics (age and degree level) and the characteristics of children and their families (gender, minority status, socioeconomic status, and prior achievement).

We present four models for each of the cognitive assessments administered to children at the end of the 1st grade (reading, mathematics, and general knowledge). The first model includes a measure of children's achievement at the end of kindergarten, as well as a measure of the amount of time that elapsed between the kindergarten and first-grade assessments. We then include teacher and student controls in Model 2, our measures of teacher qualifications in Model 3, and a set of interactions terms to test whether the effects of teacher qualifications vary with

children's socioeconomic status in Model 4. We enter interaction terms using a stepwise procedure and report only those interactions that are statistically significant.

3. Data

Data for this study come from the Early Childhood Longitudinal Study, Kindergarten Class of 1998–1999 (ECLS-K), sponsored by the U.S. Department of Education's National Center for Education Statistics (NCES).³ ECLS-K is a longitudinal study that includes a wide range of family, school, classroom, and individual variables related to children's development and achievement in school. In the base year of the study (1998-1999), ECLS-K collected data from a nationally representative sample of about 23,000 kindergartners attending nearly 1,300 public and private schools. ECLS-K conducted follow-up assessments and surveys with these children in 2000,⁴ when children were first graders, and in 2002,⁵ when children were third graders. The longitudinal design for the study specifies additional data collection in 2004, when students will be fifth graders. We use data from the base year and first-grade follow-up in our analyses.

A unique characteristic of the ECLS-K dataset is that it provides information about children's early learning, individual and family characteristics, and the qualifications of children's teachers. Children completed individually-administered cognitive assessments about academically-related skills and content areas during the spring of their kindergarten and first-grade years. At the same time, ECLS-K collected data from children's parents, their teachers, and the administrators of participating schools about a comprehensive set of developmental and

³ We use data from the March 2002 Longitudinal kindergarten-first grade public use child file and electronic codebook (NCES 2002-148).

⁴ ECLS-K also collected data from a sub-sample of children in the fall of 1999; these data, however, are not used in this analysis.

education-related matters. Although other datasets provide more extensive information about the professional qualifications of elementary school teachers (e.g., the NCES School and Staffing Survey), ECLS-K is the only dataset to include a nationally representative, longitudinal sample of elementary school children with cognitive assessment data that can be linked to their individual teachers.

The ECLS-K data that we use in our analysis fall into three broad categories: measures of achievement, measures of teacher qualifications, and measures of student and teacher characteristics that we wish to employ as controls in our analyses.

Achievement. Our dependent variables are IRT-scale scores for cognitive assessments in reading, mathematics, and general knowledge administered to children at the end of their first-grade year. The reading assessment measures basic skills (e.g., print familiarity, beginning and ending sounds), vocabulary, and comprehension (e.g., listening comprehension, words in context); the mathematics assessment measures skills in conceptual knowledge, procedural knowledge, and problem solving; while the general knowledge assessment measures science competencies (e.g., conceptual understanding of facts, ability to form questions about the natural world, and ability to attempt to answer questions using scientific tools and evidence) and knowledge of social studies material (e.g., history/government, culture, geography, and economics). To control for prior learning, we include the IRT-scale scores for the comparable assessments administered to children at the end of their kindergarten year. Because the lag time between administrations varied for children, we also include the number of days that elapsed between the kindergarten and first-grade assessments in our analyses. We standardized the assessment measures and centered the measure of elapsed time on its mean (roughly 366 days).⁶

⁵ The data for the third-grade assessment of children have not been released yet.

⁶ See the Appendix for a full description of all variables used in this analysis.

Teacher qualifications. ECLS-K provides a range of information about the qualifications of children's first-grade teachers, including highest degree attained, degree type, certification status and the number of years that teachers taught first grade. We were especially interested in developing a set of variables that would parallel variables used in studies that examined the effects of teacher qualifications on achievement at the secondary level (see Goldhaber & Brewer 1996, 1998, 2000). Consistent with these studies we constructed an indicator of teachers' certification status (regular or alternative v. none, temporary, provisional, emergency or probational) and a continuous measure of teachers' experience (number of years teachers taught first grade). We centered the measure of teacher experience on its mean (about 8 years).

These studies also emphasize the importance of using subject-specific rather than general degree variables in models that estimate the effects of teacher qualifications on student achievement. However, elementary education teacher preparation programs are not as subject-specific as secondary teacher preparation programs. Although professional organizations, such as the National Council of Teaching of Mathematics (NCTM) and the International Reading Association (IRA), have pressed for subject-specific coursework for elementary school teachers, subject-specific degrees are relatively rare at the elementary level; more common are degrees that prepare teachers to work with different grades of children (e.g., early childhood education v. elementary education). We focus on elementary education degrees in this study because they are the modal degree for elementary school teachers, including those in the ECLS-K sample; we also speculate that teachers with elementary education degrees complete more subject-specific coursework as part of their preparation programs than teachers with other education degrees.⁷ We constructed three indicators for the degrees that teachers hold: teachers with an

undergraduate degree in elementary education (BA but less than an MA); teachers with a graduate degree in elementary education (MA or higher); and teachers with a graduate degree in any area (MA or higher). The comparison is with teachers whose highest level of educational attainment is an undergraduate degree in any area except elementary education. When these three indicators are included in the model it allows us to observe the value added by having an “in-field” degree (i.e., a degree in elementary education) or an advanced degree.

Related measures. We control for various characteristics of students and teachers that might serve as alternative explanations for the effects of teachers’ qualifications on first-grade achievement. In addition to prior achievement and the elapsed time between assessments, we include in our models indicators for children’s gender (female v. male) and minority status (minority v. non-minority), as well as a continuous measure of their family’s socioeconomic status (SES). Because teacher qualifications may be related to teachers’ age, we also constructed a linear and a non-linear measure of teachers’ age (in years). In our analysis, we standardized the measure of children’s socioeconomic status and centered teachers’ age on its mean (approximately 42 years).

We restricted our sample to children in the 1998-1999 kindergarten cohort who participated in the first-grade assessments and attended a public elementary school during the 1999-2000 school year. Of these 12,750 children, 70 percent have full assessment data for all subject areas, as well as data for all of the other variables included in our models. Our final sample consists of 8,933 children. We normalized the cohort weight to this sample and used the weight in our analyses. This final sample has higher levels of kindergarten and first-grade achievement for all of the cognitive assessments, with differences in achievement ranging from

⁷ This was confirmed by an earlier analysis that showed that teachers with elementary education degrees reported having taken higher numbers subject-specific courses than teachers with other education-related degrees (e.g., early

.04 SD to .08 SD (compared to the public elementary school sample).⁸ There are also fewer non-minority children (37 percent v. 42 percent) and fewer teachers with graduate degrees (38 percent v. 40 percent) in the final sample. We found no difference, however, in the other demographic characteristics of children; nor did we find any difference between the public school sample and the final sample in teachers' age, years of first-grade experience, certification status, or degree type.

4. Findings

Descriptive analyses. Table 1 provides general descriptive information for all variables used in our analyses, as well as comparisons between children taught by teachers with and without a degree in elementary education. Most children are taught by first-grade teachers with an elementary education degree (84 percent).⁹ Children taught by teachers with an elementary-education degree have somewhat higher levels of achievement at both the end of kindergarten and the end of the first grade, though these differences are neither large nor consistent. Children taught by teachers with a degree in elementary education have higher first-grade assessment scores in mathematics (a difference of 0.10 SD) and general knowledge (0.15 SD) but no advantage in first-grade assessment scores for reading. The pattern for kindergarten assessment scores is slightly different, with children taught by teachers with non-elementary education degrees having *higher* levels of achievement in reading (0.07 SD) but lower levels of achievement in general knowledge (-0.16 SD). There is no difference in first-grade mathematics achievement, nor is there a difference in the lag time between the administrations of assessments.

childhood or special education).

⁸ Based on two-tailed *t*-tests with statistical significance < .05.

Table 1 about here

Children taught by teachers with and without an elementary education degree also have relatively similar demographic characteristics, though their teachers differ slightly in age and educational attainment. Although minority children are somewhat more likely than non-minority children to have first-grade teachers without an elementary education degree (47 percent v. 35 percent), the likelihood for male and female children, as well the likelihood for economically advantaged and disadvantaged children, is the same. Children taught by teachers without an elementary education degree are more likely to be taught by younger teachers (on average, a teacher two years younger). Virtually all of the children in our sample have teachers with at least an undergraduate degree,¹⁰ but children taught by teachers without a degree in elementary education are less likely to be taught by teachers with a graduate degree (25 percent v. 41 percent).¹¹

Of particular interest to us, given the focus of our paper, is whether there are additional differences in teacher qualifications for these two groups of children. Although the vast majority of children in the sample are taught by certified teachers (92 percent), some children are not. Those who are not are more likely to be taught by teachers without an elementary education degree (87 percent v. 93 percent). Teachers without a degree in elementary education also

⁹ About one-third of the children in the sample have teachers with a non-education degree (35 percent); the remaining children have teachers with either a degree in early childhood education (47 percent) or a degree in a subspecialty, such as special education (18 percent).

¹⁰ Of the 8,933 children in the sample, nine have teachers with an Associate's degree.

¹¹ Approximately 11 percent of teachers with an undergraduate elementary education degree hold a graduate degree in some other area of study.

possess fewer years of first-grade teaching experience (about two years less experience than teachers with a degree in elementary education).

Effects on reading achievement. Tables 2 – 4 report the effects of teacher qualifications on children’s first-grade achievement (reading, mathematics, and general knowledge respectively). Because the dependent variable is standardized, the coefficients can be interpreted as effect sizes (or the percentage of a SD attributable to a unit change in each independent variable). The first column (Model 1) presents the base model, the second column (Model 2) introduces student and teacher controls to the base model, the third column (Model 3) adds teacher qualifications, and the fourth column (Model 4) tests for interaction effects between teacher’s qualifications and the children’s socioeconomic status.

Table 2 about here

As indicated by Table 2, Model 1, prior achievement has the strongest effect on how much children learn in reading. The effect of prior achievement is roughly 0.74 SD and remains relatively unchanged in subsequent models. The longer the elapsed time between the kindergarten and first-grade reading assessment, the higher the first-grade IRT-scale score. In other words, the more time children had to learn, the more they learned in reading. A time lag difference of ten days is equal to an increase of approximately 0.04 SD on the first-grade reading assessment.

Model 2 provides the effects associated with our two sets of student and teacher controls. Female children scored higher than male children on the first-grade reading assessment (a difference of 0.06 SD), regardless of prior achievement. Non-minority children also scored

higher than minority children on the assessment (0.10 SD). Moreover, children from more advantaged backgrounds learned more than children from disadvantaged backgrounds (the difference being roughly 0.10 SD for a student 1 SD above the mean for SES). There is also a non-linear effect of teachers' age on reading achievement. Generally, as teachers approach the mean age (42 years), age has a positive influence on reading achievement, but as teachers get older than the mean age, the positive effects of age diminish. There is no effect of having obtained a graduate degree, not without specifying the area of study.

Models 3 and 4 present the effects of teacher qualifications on reading achievement. Because there is a significant interaction between certification status and SES, Model 4 provides the best estimates of the effects of teacher qualifications on first-grade reading achievement. After controlling for all of the other variables in the model, children taught by a certified first-grade teacher have higher assessment scores (a difference of roughly 0.06 SD), as do children taught by teachers with either an undergraduate or graduate degree in elementary education (0.05 SD and 0.06 SD respectively). Children taught by teachers with more first-grade experience also achieve more in reading than children taught by teachers with less experience. A difference of ten years of experience is equal to about 0.08 SD gain in reading scores.

While first-grade children in general benefit from being taught by more qualified teachers, first-grade children from disadvantaged backgrounds appear to benefit the most from their teachers' certification status. Although the effect of certification status is about 0.06 SD for children from average-SES households, the effect of certification status is twice as large for children from low-SES households (0.12SD).¹² It is also worth noting that the introduction of the interaction term in Model 4 increases the effect of SES by roughly 60 percent (from 0.10 SD

¹² We define a low-SES household as students coming from a family -1 SD below the mean for SES. The effect of certification status for children from a low-SES household would be $[0.06 + (-1 \times -0.06)]$ or 0.12 SD.

in Model 3 to 0.16 SD in Model 4). In other words, the effects of SES on first-grade reading achievement are greatest for children who are taught by uncertified teachers.

Effects on mathematics achievement. Table 3 presents the results of our analysis of the effects of teacher qualifications on mathematics achievement. As with reading achievement, children's prior knowledge has the strongest effect on children's mathematics scores at the end of the first grade (0.75 SD). The effect is relatively constant and unaffected by the inclusion of student and teacher controls in Model 2 or teacher qualifications in Model 3. Elapsed time also has a positive effect on children's acquisition of mathematics' knowledge and skills. A time lag difference of ten days is equal to an increase of approximately 0.03 SD on the mathematics assessment.

Table 3 about here

Model 2 introduces controls for student and teacher characteristics. Although female children outperform male children on the assessment of reading, the reverse is true for mathematics. Male children have assessment scores roughly 0.04 SD higher than the assessment scores of female children. There continues to be an achievement gap between minority and non-minority children (the difference being -0.12 SD). The more advantaged the family background of children, the higher the level of mathematics achievement (0.08 SD). There are no effects for teachers' age or graduate education, but, as Model 3 indicates, these effects change when we introduce teacher qualifications into the analysis. Although there is no non-linear effect for age, the linear effect suggests that children taught by younger teachers acquire more mathematics knowledge than teachers taught by older teachers, once we enter teacher qualifications into the

analysis. The effect for children of teachers who have a graduate degree also becomes statistically significant but *negative* (-0.07 SD)!

Because there are no statistically significant interactions between teacher qualifications and children's socioeconomic status, Model 3 provides the best estimates for the effects of teacher qualifications on the mathematics achievement of first graders. Unlike with reading, certification status has no effect on children's mathematics' achievement, but there are positive effects associated with degrees in elementary education and teachers' years of experience. Children taught by teachers with an undergraduate degree in elementary education outscore children taught by teachers with comparable degrees in other areas by 0.06 SD, whereas children taught by teachers with a graduate degree in elementary education outscore children taught by teachers with undergraduate degrees in other areas by 0.07 SD.¹³ These effects are nearly twice as large if compared to students taught by teachers with graduate degrees in other areas (0.13 SD and 0.14 SD respectively). Children taught by more experienced teachers also have higher year-end assessment scores. A difference of ten years of experience is equal to an increase of about 0.03 SD on the mathematics assessment.

Effects on general knowledge achievement. Table 4 presents our findings for the effects of teacher qualifications on the acquisition of general knowledge. These findings generally mirror those for other outcomes that we examined. Prior achievement has the strongest effect on children's cognitive assessment scores at the end of the first grade (0.83 SD), and these effects are relatively unchanged in subsequent models. The more time that elapsed between assessments, the higher the assessment scores. A time lag difference of ten days is equal to roughly a 0.03 SD increase in assessment scores.

¹³ Because the teachers with graduate degrees in elementary education also have a graduate degree in any area, the effect of a graduate degree in elementary education is the sum of these effects (-0.07 SD + 0.14 SD or 0.07 SD).

Table 4 about here

The effects for gender are similar to those reported for mathematics, with male children having higher assessment scores than female children (0.06 SD). Minority children also have lower assessment scores than non-minority children (-0.11 SD) on the assessment of general knowledge, as do children from less advantaged backgrounds (-0.07 SD). The effects for teachers' age suggest that children taught by mid-age teachers learn more about science and social studies materials than children taught by either younger teachers or older teachers. These effects change slightly with the introduction of additional variables in Models 3 and 4, but the non-linear pattern for the effect remains the same and significant.

Because we found an interaction between socioeconomic status and years of experience teaching first grade, Model 4 provides the best estimates for the effects of teacher qualifications on children's early learning in science and social studies. Children taught by certified teachers learn more (0.05 SD) than children taught by uncertified teachers, but there are no effects associated with either degree level or type. There is also a positive effect associated with teachers' experience, with a difference of ten years of experience being equal to about a 0.02 SD increase on the general knowledge assessment. The negative interaction between experience and SES indicates that the effects of SES on early learning are slightly weaker when children are taught by an experienced teacher. The effect of SES for disadvantaged children taught by a beginning teacher is -0.10 SD, whereas the effect of SES for disadvantaged children taught by a teacher with ten years of experience is -0.08 SD.

5. Conclusions

Our investigation of teacher qualifications and the effects on early learning generate several key findings. First, teacher qualifications matter! Children taught by teachers with higher qualifications achieve more by the end of the first grade than children taught by teachers with lower qualifications, regardless of the subject area that we examined. While not all indicators of quality are equally important for all subject areas, the most important indicators of quality are certification status, degree type, and years of first-grade experience. These findings differ from those that have discovered no discernable effects for specific teacher qualifications at the elementary level (e.g., Link & Ratledge, 1979; Murnane & Phillips, 1981).

Similar to studies of the effects of teacher qualifications at the secondary level (Goldhaber & Brewer, 1997a, 1997b, 1998, 2000), we found that specific degrees are more positively related to student achievement than general degrees. Children taught by teachers who acquired elementary education degrees learn more in reading and mathematics, albeit not general knowledge, than children who are taught by teachers who acquired degrees in some other area. Although elementary school teachers are less likely to specialize in specific subjects than secondary school teachers, degree type still influences achievement outcomes, particularly in core curricular areas. Our most consistent influence on children's achievement was teachers' first-grade experience. This finding is consistent with that reported by Rowan, Correnti, and Miller (2002), using *Prospects* data and a multilevel methodology.¹⁴

Second, teacher qualifications influence reading achievement, arguably the focus of early elementary education, the most. Certification status, degree type, and years of experience are all

¹⁴ The ECLS-K data are nested, like the *Prospect* data, and may require a multilevel methodology to accurately disentangle student, teacher, and school effects. In our analytic sample, there are roughly three students per teacher and three teachers per school, with one-third of the schools having only one teacher. The results we report here are exploratory; we plan to investigate alternative methodologies in future analyses.

associated with children's acquisition of reading skills, vocabulary, and comprehension. We found weaker, though still statistically significant effects, associated with teacher qualifications and children's gains in mathematics achievement and acquisition of science and social studies knowledge. Degree type and teacher experience had positive effects on mathematics achievement, as did certification status and teacher experience on gains in general knowledge. Current federal and state policies emphasize the importance of raising achievement levels in reading; our findings suggest that hiring and retaining qualified teachers should be important components of a policy initiative designed to achieve this goal.

Third, while teacher qualifications are an important consideration for all students, our findings support arguments made by Darling-Hammond (1996, 2000) – that teacher qualifications matter especially for children from socially disadvantaged backgrounds. Certification status was more important for low-SES children than high-SES children in reading, and teachers' experience was more important for low-SES children than high-SES children in general knowledge acquisition. In each case, the high-teacher qualifications helped children overcome some of the negative effects on achievement associated with disadvantaged households, whereas low-teacher qualifications exacerbated these effects.

The effects of individual teacher qualifications are small, but we argue, with others (e.g., Rowan, Correnti & Miller, 2002; Sanders, 1998; Sanders & Rivers, 1996), that these effects are best understood as additive and cumulative. To understand how the additive effects of teachers' qualifications influence achievement, we constructed a series of scenarios for children from low and average-SES backgrounds. We present these results in Figure 1. In the figure we report three sets of comparisons for children from low-SES backgrounds and average-SES backgrounds

taught by teachers with high and low qualifications.¹⁵ Children from low-SES backgrounds taught by teachers with high qualifications outscore their counterparts taught by teachers with low-teacher qualifications by 0.25 SD in reading, 0.10 SD in mathematics, and 0.09 SD in general knowledge. Moreover, in reading and mathematics, the positive effects of teacher qualifications counterbalance the negative effects of coming from a low-SES household (-1 SD), with low-SES children attaining achievement gains equal to or higher than the average for all children. Children from average-SES backgrounds outscore their counterparts taught by teachers with low qualifications by 0.19 SD in reading, 0.10 SD in mathematics, and 0.07 SD in general knowledge. While these are still modest effects in magnitude, if repeated over six years of elementary school, they would range from 1.50 SD to 0.42 SD, magnitudes that certainly warrant the attention of education researchers and policymakers.¹⁶

Our study also raises a number of questions about the effects of teacher qualifications on achievement. Although we found evidence that teacher qualifications are related to first-grade achievement outcomes, we have not shed any light on the actual processes through which qualifications become transformed into high-quality teaching in the classroom. Do teachers with high qualifications engage in more powerful instructional practices than teachers with low qualifications? Do they have deeper, more principled content knowledge of specific subject areas, like reading; are they more motivated, committed, and professionally engaged in teaching; or are they better at managing classroom behaviors and school-family relationships than teachers with low qualifications? While certification status, degree type, and experience serve as

¹⁵ We define low-SES as 1 SD below the mean. High-teacher qualifications include certified teachers, teachers with ten years of experience, and teachers with a graduate degree in elementary education; low-teacher qualifications include uncertified teachers, beginning teachers (< one year), and teachers with a degree in an area other than elementary education. In calculating effects, we exclude minority status and gender, and we set prior achievement, elapsed time, and teachers' age to their respective means.

important proxies for teacher quality, they do not identify the important processes by which these qualifications influence teaching and early learning. If teacher qualifications are also related to positive teacher beliefs and practices, it would further reinforce their importance as indicators of quality for policymakers and school decision-makers.

Finally, we discovered a puzzling negative effect of advanced degrees in areas other than elementary education on first-grade mathematics achievement. While it is difficult to interpret this finding, it is not without precedent. Rowan, Correnti, and Miller (2002), using the *Prospects* data and multilevel methods, found advanced academic preparation in mathematics to be negatively associated with children's gains in mathematics achievement through the elementary grades. Although our dataset does not allow us to determine whether teachers are certified in specific subject areas, it is possible that our finding taps a relationship similar to that discovered in the *Prospects* data. If so, these findings may indicate that under some circumstances advanced education is not simply unrelated to quality, it may actually interfere with or diminish the quality of teaching in classrooms. We suggest that such a finding warrants further investigation by education researchers.

¹⁶ For these estimates we assume a constant effect of teacher qualifications across grades and time; it is, of course, possible that effects will vary by grade and time. We plan to investigate this using subsequent waves of ECLS-K data.

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APPENDIX

Summary of Variables Used in Analysis

Spring kindergarten and first-grade IRT-scale scores (reading, mathematics, and general knowledge). Children were administered an untimed, individualized assessment in each subject area using computer adaptive testing. For each assessment, children were asked either to point to items on an easel or respond orally to items administered by a trained assessor. Children completed a routing test in each subject area composed of items asked of all students. Children's performance on the routing test was used to determine which second-stage test was most appropriate in difficulty. IRT-scale scores were calculated for each subject area based on children's performance on the routing and second-stage tests. The mathematics and general knowledge two-stage assessment batteries were identical in the kindergarten and first-grade year. The kindergarten and first grade reading batteries were similar, with the exception that the number of reading items was increased in first grade with more difficult vocabulary words and text to eliminate the possibility of ceiling effects. For the purposes of this paper, the IRT-scale scores were standardized, with a mean of zero and a standard deviation of 1. The range of standardized scores on each measure is presented below, along with a description of each subject area.

- a. *Reading assessment* – designed to measure basic skills (e.g., print familiarity, beginning and ending sounds), vocabulary, and comprehension (e.g., listening comprehension, words in context). Standardized scores on this measure ranged from –2.05 to 5.08 in kindergarten and from –3.24 to 2.55 in first grade.

- b. *Mathematics assessment* – designed to measure skills in conceptual knowledge, procedural knowledge, and problem solving. Standardized scores on this measure ranged from –2.44 to 3.87 in kindergarten and from –6.18 to 1.93 in first grade.

- c. *General knowledge assessment* – designed to measure science competencies (e.g., conceptual understanding of facts, ability to form questions about the natural world, and ability to attempt to answer questions using scientific tools and evidence) and social studies material (e.g., history/government, culture, geography, and economics). Standardized scores on this measure ranged from –2.67 to 2.82 in kindergarten and from –3.69 to 2.01 in first grade.

Elapsed time. Continuous variable that ranges from 279 to 438 days between spring kindergarten and spring first grade assessments, with a mean of 365.7 days. Elapsed time was calculated by 1) converting the assessment date variables on the data file into numeric date format, 2) subtracting the numeric date value for the spring kindergarten assessment from the date value for the spring first-grade assessment, and 3) dividing the difference by 86400 to determine elapsed time in days. For the regression analyses, elapsed time was centered on the mean number of days of elapsed time between the two cognitive assessments.

Student's gender. Dummy coded, 1 = female, 0 = male. Forty-nine percent (49.3%) are female.

Student's minority status. Dummy coded, 1 = non-white, 0 = white, non-Hispanic.

Thirty-seven percent (37.1%) are non-white.

Student's socioeconomic status (SES). Continuous, standardized variable with a mean of zero and standard deviation of 1. The SES variable is a composite on the ECLS-K data file based on the following variables: mother/female guardian's education level, father/male guardian's education level, mother/female guardian's occupation, father/male guardian's occupation, and household income. Children's SES values range from -3.84 to 3.75.

Teacher's age. Continuous variable that ranges from 23 to 65, with a mean age of 41.7 years. For the regression analyses in this paper, teachers' ages were centered on the mean age and a nonlinear age variable was also included in the model (centered age squared).

Teacher's years of first-grade teaching experience. Continuous variable that ranges from 0 to 30 years, with a mean of 8.4 years. For the regression analyses, years experience was centered on the mean number of years of first-grade experience.

MA plus (any area). Teacher's highest degree is a MA or higher in any area of study. Dummy coded, 1 = master's degree/educational specialist/doctoral degree, 0 = bachelors or lower degree. Thirty-eight percent (38.4%) of children's teachers hold a masters or higher degree.

BA plus (elementary education). Teacher's highest degree is a BA but less than an MA in elementary education. Dummy coded, 1 = undergraduate but no graduate degree in elementary education, 0 = no undergraduate degree in elementary education or has a graduate degree in elementary education. Fifty-eight (58.3%) of children's teachers hold an undergraduate but no graduate degree in elementary education. This includes 9 teachers with an Associates degree who reported having obtained a BA degree in elementary education.

MA plus (elementary education). Teacher's highest degree is a MA or higher in elementary education. Dummy coded, 1= graduate degree in elementary education, 0 = no graduate degree in elementary education. Twenty-six (25.6%) of children's teachers hold a graduate degree in elementary education.

Teacher is certified. Dummy coded, 1 = teacher holds an alternative program certificate or a regular teaching certificate, 0 = teacher holds no teaching certificate or holds a temporary, provisional, emergency, or probational teaching certificate. Ninety-two percent (92.5%) of children's teachers are certified.

Table 1 Characteristics of Students' Teachers With and Without Degrees in Elementary Education (n = 8,933 students) ^a

	No Degree in Elementary Education (16.0%)	Degree in Elementary Education (84.0%)	All Teachers (100%)
Dependent Variables			
1 st grade achievement			
Reading	-0.02	0.00	0.00
Mathematics	-0.08	0.02 ^{**}	0.00
General knowledge	-0.13	0.02 ^{***}	0.00
Prior achievement			
Kindergarten achievement			
Reading	0.06	-0.01 [*]	0.00
Mathematics	-0.01	0.00	0.00
General knowledge	-0.13	0.03 ^{***}	0.00
Elapsed time	365.21	365.81	0.00
Student & Teacher Controls			
Student			
Female	47.06	49.71	49.29
Minority status	47.44	35.11 ^{***}	37.08
SES	0.04	-0.01	0.00
Teacher			
Age	39.86	42.01 ^{***}	41.67
MA plus (any area)	25.00	41.00 ^{***}	38.45
Teacher Qualifications			
Certified	87.21	93.47 ^{***}	92.47
BA plus (elem. education)	0.00	69.49 ^{***}	58.40
MA plus (elem. education)	0.00	30.51 ^{***}	25.64
Years experience 1 st grade	6.46	8.72 ^{***}	8.36

* $p < .05$; ** $p < .01$; *** $p < .001$ using two-tailed t -tests.

^a n is unweighted. Continuous variables are standardized as z-scores. Age and elapsed time are centered on their respective means. Female, minority status, MA plus, BA plus (elementary education), and MA plus (elementary education) are dummy coded.

Table 2 Effects of first-grade grade teachers' qualifications on students' first-grade reading achievement (n = 8,933 students) ^a

	Model 1 <i>Base Model</i>	Model 2 <i>Student & Teacher Controls</i>	Model 3 <i>Teacher Qualifications</i>	Model 4 <i>Interactions with SES</i>
Constant	- 0.0000	0.0198	-0.0753*	-0.0663*
Base Model				
Prior achievement (spring of kindergarten)	0.7370***	0.6912***	0.6911***	0.6910***
Elapsed time	0.0035***	0.0035***	0.0034***	0.0035***
Student & Teacher Controls				
Student				
Female		0.0581***	0.0552***	0.0550***
Minority status		-0.0961***	-0.0824***	-0.0819***
SES		0.0998***	0.1004***	0.1595***
Teacher				
Age		0.0001	-0.0034***	-0.0034***
Non-linear age		-0.0001*	-0.0002*	-0.0002*
MA plus (any area)		0.0081	-0.0119	-0.0116
Teacher Qualifications				
Certified			0.0637*	0.0564*
BA plus (elem. education)			0.0496*	0.0472*
MA plus (elem. education)			0.0592*	0.0562*
Years experience 1 st grade			0.0075***	0.0076***
Qualifications by SES Interactions^a				
Certified by SES				-0.0644*
R²	0.5430	0.5570	0.5600	0.5600

* $p < .05$; ** $p < .01$; *** $p < .001$

a Coefficients reported in effect sizes. All continuous measures are coded as z-scores on the entire population of public school students with valid data for all variables. Only statistically significant interactions included in the final model.

Table 3 Effects of first-grade grade teachers' qualifications on students' first-grade mathematics achievement (n = 8,933 students)^a

	Model 1 <i>Base Model</i>	Model 2 <i>Student & Teacher Controls</i>	Model 3 <i>Teacher Qualifications</i>	Model 4 <i>Interactions with SES</i>
Constant	- 0.0000	0.0656 ^{***}	0.0237	---
Base Model				
Prior achievement (spring of kindergarten)	0.7497 ^{***}	0.7037 ^{***}	0.7038 ^{***}	---
Elapsed time	0.0034 ^{***}	0.0034 ^{***}	0.0033 ^{***}	---
Student & Teacher Controls				
Student				
Female		-0.0413 ^{**}	-0.0435 ^{**}	---
Minority status		-0.1161 ^{***}	-0.1079 ^{***}	---
SES		0.0816 ^{***}	0.0835 ^{***}	---
Teacher				
Age		-0.0007	-0.0019 [*]	---
Non-linear age		0.0000	-0.0000	---
MA plus (any area)		-0.0061	-0.0659 ^{**}	---
Teacher Qualifications				
Certified			-0.0069	---
BA plus (elem. education)			0.0629 ^{**}	---
MA plus (elem. education)			0.1410 ^{***}	---
Years experience 1 st grade			0.0026 ^{***}	---
Qualifications by SES Interactions^a				
None				---
R²	0.5589	0.5694	0.5709	---

* $p < .05$; ** $p < .01$; *** $p < .001$

a Coefficients reported in effect sizes. All continuous measures are coded as z-scores on the entire population of public school students with valid data for all variables. No interactions with SES were statistically significant, so Model 4 is not presented.

Table 4 Effects of first-grade grade teachers' qualifications on students' first-grade general knowledge achievement (n = 8,933 students)^a

	Model 1 <i>Base Model</i>	Model 2 <i>Student & Teacher Controls</i>	Model 3 <i>Teacher Qualifications</i>	Model 4 <i>Interactions with SES</i>
Constant	0.0000	0.0936 ^{***}	0.0415	0.0429
Base Model				
Prior achievement (spring of kindergarten)	0.8263 ^{***}	0.7724 ^{***}	0.7712 ^{***}	0.7710 ^{***}
Elapsed time	0.0025 ^{***}	0.0025 ^{***}	0.0024 ^{***}	0.0025 ^{***}
Student & Teacher Controls				
Student				
Female		-0.0625 ^{***}	-0.0636 ^{***}	-0.0638 ^{***}
Non-white		-0.1082 ^{***}	-0.1045 ^{***}	-0.1032 ^{***}
SES		0.0721 ^{***}	0.0726 ^{***}	0.0876 ^{***}
Teacher				
Age		0.0025 ^{***}	0.0012	0.0012
Non-linear age		-0.0002 ^{**}	-0.0002 ^{**}	-0.0002 ^{**}
MA plus (any area)		-0.0109	-0.0236	-0.0235
Teacher Qualifications				
Certified			0.0489 [*]	0.0472 [*]
BA plus (elem. education)			0.0101	0.0105
MA plus (elem. education)			0.0224	0.0217
Years experience 1 st grade			0.0023 [*]	0.0024 ^{**}
Qualifications by SES Interactions^a				
SES by years experience				-.0018 [*]
R²	0.6812	0.6907	0.6911	0.6913

* $p < .05$; ** $p < .01$; *** $p < .001$

a Coefficients reported in effect sizes. All continuous measures are coded as z-scores on the entire population of public school students with valid data for all variables. Only statistically significant interactions included in the final model.