Teacher Quality in Education Production

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What is a good teacher? Do good teachers make a difference in improving student achievement? While these are simple questions, the answers are more complex. Policymakers and educators are searching for strategies to improve student outcomes. In the US, the 2001 the No Child Left Behind Act (NCLB) requires that all classroom teachers be highly qualified. The assumption is that highly qualified teachers will produce higher measured student achievement. NCLB has set certain criteria for determining the credentials that such teachers must have, but does little to define the characteristics and skills a teacher must possess in order to be considered high quality. In fact, the research evidence on what observable teacher characteristics impact student achievement provides little guidance. In this article, we discuss empirical evidence on teacher quality in education production. Several comprehensive reviews of the literature have been conducted (see the sections titled 'Bibliography' and 'Further reading'), so our focus here is on more recent studies.

The Education Production Function

The education production function is an economic formulation of an input–output model: measured input variables, such as teacher quality, are mapped to a certain measured output, usually student achievement test scores or test score gains. Although a few experimental studies exist (e.g., Glazerman *et al.*, 2006), the empirical estimation of education productions is typically via multivariate regression models in quasi-experimental or nonexperimental settings. Hence, the vast bulk of the research evidence is able to detect correlational relationships between various characteristics and student achievement, with no or weak inferences about causal effects. Further, early studies of education production were typically conducted at an aggregate level – for example, examining mean years of teaching experience or the percentage of teachers with certification, in a school or district. More recent research has been able to take advantage of student-level longitudinal data in which it is possible to identify the characteristics of the specific teacher that taught a particular student.

The landmark study by Coleman *et al.* (1966), *Equality of Educational Opportunity* (also known as the Coleman report), which was commissioned by the US federal government, is among one of the most widely known education production studies. Coleman found that measured school resources explained a small portion of the variance in student achievement. This finding was (mis)interpreted to mean schools do not matter. However, the main issue is whether there exist systemic differences in the ability of schools and teachers to raise student achievement (Hanushek *et al.*, 2005). Many researchers have demonstrated that schools matter a great deal (Clotfelter *et al.*, 2006; Rivkin *et al.*, 2005) and that teacher quality is the single most important factor among all school-related components (Hanushek, 2002; Rivkin *et al.*, 1998; Sanders and Rivers, 1996). Not only can teachers positively impact their students (Goldhaber, 2007; Clotfelter *et al.*, 2006), a series of high-quality teachers can potentially mitigate socioeconomic inequalities for individual students. Hanushek (2002) notes that "schools have the ability to compensate for educational differences arising from family backgrounds [where a long] string of above average teachers can entirely close the achievement gap, by income level" (p. 27). However, there are large differences in teacher impact on student achievement and identifying the high-quality teachers is problematic.

What Is Teacher Quality?

The majority of production function research assumes that observable characteristics of teachers are important determinants of student achievement. Teacher quality is a combination of observable and unobservable characteristics (Goldhaber and Anthony, 2007; Rivkin *et al.*, 2005; Hanushek *et al.*, 2005). For example, two easily observable teacher characteristics are years of experience and degree level (Boyd *et al.*, 2006; Clotfelter *et al.*, 2006; Glazerman *et al.*, 2006; Hanushek *et al.*, 2005; Rivkin *et al.*, 2005; Rockoff, 2004). These two variables are typically the basis for paying teachers in the US and hence commonly collected information. More refined measures may also be utilized including the degree major or coursework, in an attempt to determine the importance of subject-matter knowledge or pedagogical training. Other characteristics include proxies for ability such as the quality of the college or university (indicated by the selectivity of the institution) attended by the teacher (Murnane and Phillips, 1981; Ehrenberg and Brewer, 1994; Clotfelter *et al.*, 2006; Glazerman *et al.*, 2006), or tests of teacher ability such as scores on the National Teacher Exam, Scholastic Aptitude Test (SAT) or American College Testing (ACT) scores, or

specially designed tests (Ehrenberg and Brewer, 1994, 1995; Summer and Wolfe, 1977, 1975; Ferguson and Ladd, 1996). Similarly, various studies have examined the relationship between teacher certification and student achievement (Goldhaber and Brewer, 2000; Goldhaber, 2007; Goldhaber and Anthony, 2007).

Unobservable characteristics refer to characteristics not easily measured. Some examples may include pedagogy used by the teacher, classroom management skills, philosophy of teaching, and interpersonal or social skills (Goldhaber and Anthony, 2007; Glazerman *et al.*, 2006; Rockoff, 2004). Goldhaber *et al.* (1999) estimate that as much as 97% of teacher effects are attributable to unobservable characteristics. Data are typically not available for most of these factors, and it is difficult to separate them out conceptually or design policy interventions that can affect them with much certainty. In the next section, we focus, therefore, on the variables most commonly studied: teacher experience, certification, subject-matter preparation, advanced degrees held, and ability.

Teacher Experience

Many education production studies have examined whether or not teacher experience matters. Given data limitations, research is typically able to simply count a teacher's number of years of experience, treating all years as identical; hence, there is usually no information on the quality of any given year of experience. While hundreds of education production studies have been conducted since the Coleman report, they have not necessarily reached similar conclusions. Hanushek (1986), one of the most widely cited reviews of education production literature, concluded that there was no strong evidence that a teacher's years of experience positively effects student achievement; for example, in his 1989 update on school expenditures and performance, he found that only 29% of the 140 studies that included teacher experience as an input had statistically positive coefficients (Hanushek, 1989). However, Greenwald *et al.* (1996), in their own review of similar studies found experience was related to student achievement. These divergent conclusions are explained largely by differences in weighting of the studies and methodologies used to aggregate the results (Eide *et al.*, 2004).

The consensus view is that the experience gained in the first few years of teacher's career are the most important. In other words, a teacher's learning curve is steep (Murnane, 1975; Boyd *et al.*, 2006; Clotfelter *et al.*, 2006; Hanushek *et al.*, 2005; Rivkin *et al.*, 2005; Rockoff, 2004). The issue is whether some years of experience matter more than others, and if so, which ones. Although there is disagreement about the number of years that makes a difference, studies show that most improvement occurs in the earlier years. Rivkin *et al.* (2001) find that students' learning gains are small after their teacher's first few years of experience. Rockoff (2004) measures the impact of individual teachers on student achievement by using panel data that matches student test scores to teacher assignment, and finds that teaching experience significantly improves student outcomes, but only in the first few years. After teachers reach the cutoff point of about 10 years, teaching experience offers only marginal returns (Rockoff, 2004). According to Rockoff (2004), reading scores in particular differ by approximately 0.17 standard deviations on average between beginning teachers and teachers with 10 or more years of experience.

Similarly, Rivkin *et al.* (2005) suggest that beginning teachers perform worse than more experienced teachers and find important gains in teacher quality after the first year of experience. They suggest that teachers early in their careers engage in learning by doing, finding little evidence that improvement continues after the first 3 years of teaching (Rivkin *et al.*, 2005). Furthermore, they suggest that the effects of nonrandom selection – where lower-quality teachers stay in the profession and more talented teachers exit the profession – affect the average quality of the teaching pool (Goldhaber, 1997; Hanushek *et al.*, 2005). They also suggest that teachers "may vary [their] efforts systematically with experience in response to tenure decisions or other institutional and contractual issues," and this could also affect student achievement (p. 17). Consistent with other studies, Clotfelter *et al.* (2006) examine teacher experience and find student achievement peaking in classrooms with teachers that have between 13 and 26 years of experience. The purpose of their study is to examine teacher effectiveness given that the matching of teacher and student is nonrandom (Clotfelter *et al.*, 2006). Taken together, these studies provide strong evidence that the early years of teaching matter a great deal, and observable effects of over 10 years of experience are quite small or negligible (Clotfelter *et al.*, 2006; Hanushek *et al.*, 2005; Rockoff, 2004).

Teacher Certification

The minimum requirement for teaching in most states in the US is some form of certification. Discussions of teacher certification and preparation programs are inherently complex because of the wide variation in requirements (Darling-Hammond and Youngs, 2002). Earlier studies looking at teacher education do not necessarily separate teacher certification from subject-matter preparation and degree (Hanushek, 1994, 1989, 1986). Although teacher certification is required, there is little evidence from which to determine whether or not teacher certification itself has a significant impact on student achievement (Boyd *et al.*, 2007).

Studies on teacher certification find conflicting evidence. Goldhaber and Brewer (2000) find that students of teachers with standard certification in mathematics had higher achievement than students of teachers who are not credentialed in their subject area. Yet, the authors also find that mathematics and science students with emergency credentialed teachers do no worse than student of teachers with standard credentials, suggesting that simply having a standard credential does not make for a high-quality teacher, rather, having teachers credentialed in their subject area is what makes a difference. Unfortunately, studies of certification are hampered by the lack of good data that actually describe the content, sequencing, and quality of certification programs, which differ widely across states and from program to program within a state. Data often do not even permit clear distinctions among emergency, noncredentialed, standard, or alternative certification or credentials, making it difficult to interpret findings in a way that can improve the outcomes of the credentialing process.

In recent years, various alternative teacher certification programs, including district-sponsored programs as well as national efforts such as Teach for America (TFA), have become more widespread. According to Glazerman *et al.* (2006), TFA novice teachers are as effective in producing student achievement as other (traditional or other alternative program) novice teachers and experienced teachers alike in producing gains in math. The effect size on math scores was about 15% of a standard deviation. They also find TFA teachers are no worse than other novice and experienced teachers with respect to student achievement gains in reading (Glazerman *et al.*, 2006). This study is important because it randomly assigned teachers to students within a school district. Boyd *et al.* (2006) find small differences in gains, typically about 2–5% of a standard deviation, among students who had TFA or New York City Teaching Fellows teachers and teachers from traditional college-based teacher-preparation programs and alternative programs; however, these small differences disappear within 3 years as the teachers mature. These findings are consistent with the findings on teacher experience, and suggest the effects of teacher characteristics interact with each other in ways that are not always separable.

Degree Level and Subject-Matter Preparation

Many teachers in the United States earn advanced degrees, a plausible indicator of teacher quality. However, the consensus view is that a teacher education *per se* does not significantly impact student achievement (Hanushek, 1994, 1989, 1986; Murnane, 1975; Murnane and Phillips, 1981; Summer and Wolfe, 1975, 1977). Hanushek (1994) found that 100 of the 113 studies, including teacher education as an input, have statistically insignificant results and of the remaining 13, the positive and negative results are divided. More recently, Hanushek *et al.* (2005) and Rivkin *et al.* (2005) suggest that while advanced degrees are important for teacher compensation, they are not important for student achievement, which is consistent with earlier studies.

However, there is some evidence that advanced degrees in the subject being taught do make a difference, at least in math and science. For example, Goldhaber and Brewer (2000, 1997b) find that teachers with advanced degrees in mathematics produced greater high school student achievement in math. Similarly, Monk and Rice (1994) studied eighth-grade students and found that teachers who took several math courses in college had a positive impact on student achievement, but only when these teachers were assigned to teach more advanced math courses.

Teacher Ability

Teacher ability is another indicator of teacher quality. According to Eide *et al.* (2004), teacher ability is a stronger predictor of student achievement than years of experience or advanced degrees held. In a reanalysis of the data from the Coleman report, Ehrenberg and Brewer (1994) find a positive relationship between teacher performance on a short verbal ability test and student achievement gains. Rowan *et al.* (1997) reach a similar conclusion using one question on the National Educational Longitudinal Study (NELS) of 1998 teacher survey: those who accurately answered a math quiz item show a 0.018 effect size on student achievement in math at schools with average-ability students (Rowan *et al.*, 1997). Ferguson (1991) finds a link between student achievement and teacher's language score on the Texas Examination of Current Administrators and Teachers (TECAT). In an earlier study, Strauss and Sawyer (1986) find that a 1% increase in teacher quality, as measured by teacher test scores, results in a 5% decline in student failure rate on high school competency exams. Ehrenberg and Brewer (1994) find that students learn more from teachers who attended more selective undergraduate institutions. While Greenwald *et al.* (1996) found that teaching experience and degree levels were statistically significant and positively related to student achievement in 15% and 29% of education production function studies, respectively, they report teacher academic proficiency was positive in 50% of the studies. Although not a complete measure of teacher quality, teacher ability is clearly a quantifiable predictor of teacher effectiveness in the classroom.

Conclusion

One common theme from studies of teacher quality in education production has been a growing interest in how teacher labor markets work. If teacher quality is important in affecting student achievement, then questions pertaining to teacher attrition, retention, and recruitment become critical (Glazerman *et al.*, 2006; Boyd *et al.*, 2006; Rockoff, 2004). Similarly, how teachers are distributed across students is important. Does the sorting of teachers evolve into patterns of teacher–student matching that affect student achievement? How does this occur? The empirical evidence suggests that teacher sorting and teacher–student matching is not random (Clotfelter *et al.*, 2006; Rivkin *et al.*, 2005; Lankford *et al.*, 2002). Generally, schools in urban and low-performing districts tend to have difficulties attracting and retaining teachers (Hanushek *et al.*, 2004). In a descriptive study of teacher sorting of New York city schools, Lankford *et al.* (2002) find that these schools lose teachers to schools with more appealing environments. Some school districts find tempered relief from alternative teacher-preparation programs such as TFA and New York City Teaching Fellows, which place teachers exclusively in hard-to-staff schools with the hope to improve the educational opportunities of less-advantaged students (Glazerman *et al.*, 2006; Boyd *et al.*, 2006). More experienced and highly qualified teachers tend to be in schools that are more high performing, affluent, white, and suburban; inexperienced, less-qualified teachers work in schools that are low performing, poor, minority, and urban (Clotfelter *et al.*, 2006; Lankford *et al.*, 2002; Jacob, 2007).

Teacher sorting also occurs within schools. For example, it may be the case that tenured teachers are more able to leverage their seniority to influence teaching assignments in their favor, leaving more difficult positions to teachers with less seniority. Clotfelter *et al.* (2006) suggest that experienced teachers are better able to resist being assigned to less-able students. Yet, low-performing students are in greatest need of more experienced and effective teachers (Rivkin *et al.*, 2005). These placements in turn contribute to high teacher attrition rates among new teachers (Murnane and Steele, 2007). Unfortunately, to respond to the large numbers of vacancies, many schools place inexperienced, noncredentialed substitute teachers in classrooms. While teacher assignment policies allow this sorting practice, the distribution of teachers will continue to be uneven, favoring more-advantaged students over less-advantaged students. These distributional effects make measuring the effects of particular teacher characteristics on student achievement difficult to estimate.

The empirical estimation of education production functions has been an active research endeavor for more than 30 years. From this work, we have some important results: teaching experience in the first few years of teaching matters but not much thereafter; teacher ability (as measured by test scores or selectivity of educational institutions attended) makes a difference; advanced degrees, *per se*, are not significant but subject-matter preparation, at least in technical subjects such as math and science is probably important; and teacher certification is not likely critical at least as it currently operates in the US. Although still largely reliant on quasi- and non-experimental designs, improvements in data quality and econometric techniques have made recent results more convincing. Despite this, much remains unknown. Little progress has been made toward breaking down the largely unobserved aspects of teacher quality into more finely grained measurable characteristics, or observable behaviors that can be convincingly linked to student achievement and which can be reliably measured or even taught. Future research aiming for descriptive analysis from which more nuanced instruments of measurement could be developed and tested would further our understanding of teacher quality.

See also: Education Production Functions: Concepts; Teacher Supply; Teacher Training and Preparation in the United States.

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