Chapter 3
Teacher Qualification and the Achievement Gap: A Cross-National Analysis of 50 Countries

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Introduction

Previous studies have shown a major gap between wealthy and high-poverty students' and between white and ethnic-minority students' access to qualified teachers. High-poverty students and ethnic minority students are twice as likely as are wealthy and white students to be assigned novice teachers (Ascher and Fruchter 2001; National Center for Education Statistics 2000; Peske and Haycock 2006). Further, they are more likely to be taught by uncertified teachers (Ascher and Fruchter 2001; Darling-Hammond 2004; Shen et al. 2004), out-of-field teachers (those without a major in the subject they teach; Ingersoll 1999, 2002; Jerald and Ingersoll 2002; Akiba and LeTendre 2009), or teachers with low American College Testing (ACT) or Scholastic Assessment Test (SAT) scores (Shen et al. 2004). Teachers in high-poverty and ethnically diverse schools are also more likely to leave schools or leave the teaching profession altogether, creating a major instability in students' opportunity to learn (Ingersoll 2002). Such inequality, however, is not a problem unique to the USA. Many countries around the world are struggling with how to equalize students' access to qualified teachers (Akiba et al. 2007; UNESCO Institute for Statistics 2006).

How does the major gap in students' access to qualified teachers affect the achievement gap between students? To examine whether the level of achievement gap in a country is driven by the educational system that allows unequal distributions of qualified teachers, it is necessary to conduct a cross-national analysis using data from a large number of countries. The 2007 Trends in International Mathematics and Science Study (TIMSS) data set is the most comprehensive and recent data

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set that includes survey data from students, teachers, and principals. This data set allows us to link students' poverty level with their mathematics teachers' qualifications in order to examine the gap in students' access to qualified teachers in 50 countries.[1]

In this cross-national study, we focus on the measurable characteristics of qualifications of eighth-grade mathematics teachers that share a relatively common meaning across various cultural contexts: (a) certification, (b) mathematics major, (c) mathematics education major, and (d) teaching experience of 3 or more years. These characteristics also align with the requirements for teacher quality in the No Child Left Behind (NCLB) Act; thus, an examination of these teacher-qualification indicators in international contexts will greatly inform US policy makers.

This study is guided by the following research questions:

1. How does the percentage of eighth graders taught by qualified mathematics teachers in the USA differ from that in other countries?
2. How does the size of the gap between high-socioeconomic status (high-SES) and low-SES students in their access to qualified teachers in the USA differ from that in other countries?
3. How are the level of students' access to qualified teachers and the gap in their access to qualified teachers associated with national mathematics achievement and the SES-based achievement gap?

Background

The NCLB Act of 2001 defined *highly qualified teachers* as those who are fully certified, possess a bachelor's degree, and have demonstrated competence in subject knowledge and teaching and required that all teachers be highly qualified by the 2005–2006 academic year. Birman et al. (2009) reported that the percentage of highly qualified teachers increased from 74% in the 2004–2005 academic year to 84% in the 2006–2007 academic year. However, they also reported that the teachers who are not highly qualified are more likely to be teaching in high-poverty schools than in low-poverty schools (5 vs. 1%), in ethnically diverse schools than in white-dominant schools (4 vs. 1%), and in schools with improvement status (as a result of failing to meet Adequate Year Progress targets) than in schools without such status (6 vs. 2%).

Despite the gap in students' access to qualified teachers, a document that supplements the 2011 Quality Counts Report showed that only a small number of states implement a state policy for attracting teachers to high-poverty schools (13 states) or low-performing schools (13 states) (Editorial Projects in Education 2011). Many empirical studies have reported that students achieve better when they are taught by certified teachers, teachers with subject majors, and teachers with at least 3 years of

[1] Although Taiwan and Hong Kong are not independent countries, they are considered so in this chapter.

teaching experience (Darling-Hammond and Youngs 2002; Rice 2003; Wayne and Youngs 2003; Wilson et al. 2001, 2002). It is likely that the lack of policy focus on narrowing the gap in students' access to qualified teachers is contributing to long-lasting achievement gap in the USA.

Ensuring students' access to qualified teachers is an important goal of educational policy and reform in other countries. Policy makers in many countries are struggling with the same problems as US policy makers, such as a lack of highly qualified teachers, especially in science- and math-related subjects; low social status and salary of and poor working conditions for teachers; a lack of systemic induction programs; and inequitable distribution of qualified teachers between high-poverty and low-poverty schools (OCED 2005). The United Nations Educational, Scientific and Cultural Organization (UNESCO) also reported a severe teacher shortage in sub-Saharan African countries, the Arab states, and South Asian countries (UNESCO Institute for Statistics 2006).

Several studies have also identified variation in students' access to qualified teachers in other countries. The UNESCO Institute for Statistics (2006) examined the gap in teacher quality among isolated/rural areas, small towns, and large cities in 13 southern and eastern African countries, including South Africa, Botswana, Kenya, and Uganda. A higher percentage of students in isolated/rural areas were taught by teachers with less than 3 years of experience than were students in small towns or large cities. In addition, in Namibia, Tanzania, and Uganda, teachers in isolated/rural schools scored lower when they took a sixth-grade mathematics test than did teachers in large city schools, showing the gap in teachers' mathematics content knowledge (UNESCO Institute for Statistics 2006).

Cross-national comparative studies of teacher quality and policies and contexts influencing teacher quality revealed that the USA differs from other countries in many conditions for promoting teacher quality. A comparative study of teacher qualification using the 2003 TIMSS data showed that, whereas teachers' qualification level in the USA is about the international average, the opportunity gap in students' access to be taught by qualified teachers was the fourth largest among the 39 countries (Akiba et al. 2007). A study conducted by the Educational Testing Service compared the USA with high-achieving countries—Australia, England, Hong Kong, Japan, Korea, the Netherlands, and Singapore—in eighth-grade mathematics and science teacher education and development policies and found that all the countries except the USA and Australia had centralized systems of teacher education and certification with tighter regulatory control by the central government (Wang et al. 2003). All the above countries had screening criteria at multiple time points—entry to the teacher education program, evaluation of field experience, exit from the teacher education program, or certification—whereas in the USA, teacher licensure testing was the only major high-stakes' criterion for determining who could become a teacher.

Teacher salary also influences the quality of teacher candidates. A comparative study of teacher salary level and national achievement in 30 countries showed that US investment in the salary of experienced teachers was lower than the international average, although new teachers in the USA were paid higher than the international

average (Akiba et al. 2012). The study also found that the countries with higher average salary for experienced teachers are more likely to have higher national achievement, but the national average salary for new teachers was not significantly associated with national achievement. The low rate of growth in teacher salary in the USA may lead to a high attrition rate and instability in instructional quality and students' opportunity to learn.

A comparative study of teachers' work further revealed that US mathematics teachers are assigned to teach multiple subjects and multiple grade levels more often than are Japanese mathematics teachers, who usually teach only mathematics to only one grade level (LeTendre et al. 2001). US teachers also have a heavier instructional workload than Japanese or Australian teachers do, and they spend less time preparing for instruction (Akiba and LeTendre 2009).

Only a few cross-national comparative studies examined the gap in students' access to qualified teachers and policy and organizational contexts influencing such inequality. Akiba et al. (2007) reported a 14.4% gap (67.6 vs. 53.2%) in eighth-grade students' access to qualified mathematics teachers between high-SES students and low-SES students, compared with the international mean of 2.5% based on 39 countries. *Qualified teachers* were defined as those who are fully certified, majored in mathematics or mathematics education, and having 3 or more years of teaching experience. Akiba and LeTendre (2009) examined teacher hiring and distribution policies in Japan, Australia, and the USA and found that teacher rotation policy in Japan (in which teachers are reassigned to different schools every 4–5 years) and strong teacher incentive policy in Australia (which provides major financial incentives to those who work in remote rural schools with the greatest teacher shortage) contribute to a smaller gap in students' access to qualified teachers than in the USA.

Akiba et al. (2007) further examined the relationship between the size of the opportunity gap in students' access to qualified teachers and the achievement gap based on data from 39 countries, but the relationship was not statistically significant. They suggested that it might be due to other mediating factors in other countries, such as equal professional development opportunities and school resources, which may equalize instructional quality and ameliorate the impact of teacher-qualification gap on the achievement gap.

This study builds on the TIMSS 2003 findings by Akiba et al. (2007) and uses the 2007 TIMSS data set to examine how the level of students' access to qualified teachers and the gap in such an access between high-SES and low-SES students changed from 2003 to 2007. It is important to examine how students' opportunity to be taught by qualified teachers changed after the NCLB target year of 2005–2006 to achieve the goal of all teachers being highly qualified. The data from 50 countries allow us to see (1) where the USA stands with regard to students' access to qualified teachers and the gap in such access in comparison to 49 other countries and (2) how the USA's rank changed from 2003 to 2007. Furthermore, a cross-national analysis of the relationships (1) between students' access to qualified teachers and national achievement and (2) between the size of the gap in students' access to qualified teachers between high-SES students and low-SES students and the national

achievement gap using data from a larger number of countries (39 in 2003 vs. 47 in 2007) allows us to reexamine the potential importance of teacher qualification in influencing student learning. By examining these relationships, we attempt to provide empirical findings to inform US federal and state policy making for improving teacher quality and equalizing students' access to qualified teachers.

Method

Data

The TIMSS was developed by the International Association for the Evaluation of Educational Achievement (IEA) to measure trends in students' mathematics and science achievement in more than 50 nations around the world. This study focused on data from eighth graders and their mathematics teachers. A two-stage stratified sampling method was used to sample secondary schools first and then eighth-grade classrooms from the sampled schools. The schools were first stratified by type of school, region of the country, type of location, and percentage of minority students. A probability-proportional-to-size technique was used in the process of selecting schools to give a higher probability of selection to larger schools (Olson et al. 2009). One or two mathematics classrooms were chosen randomly from each sampled school based on the list of eighth-grade classrooms. The mathematics teachers of these classrooms were selected, and they filled out a teacher questionnaire. This study analyzed the 2007 data collected from eighth graders and their mathematics teachers in 50 countries with at least one measure of teacher qualification. The sample sizes of eighth graders and eighth-grade teachers from which the national variables were developed ranged from 3,060 students in Morocco to 7,377 students in the USA and from 116 teachers in Malta to 463 teachers in Sweden.

Measures and Analysis

We measured the national level of students' access to qualified teachers (research question 1) by the percentages of students taught by: (a) teachers with certification; (b) teachers with a mathematics major; (c) teachers with a mathematics education major; (d) teachers with 3 or more years of teaching experience; and (e) teachers with certification, a mathematics or mathematics education major, and 3 or more years of teaching experience (overall measure of teacher qualification).

Teacher-qualification data came from teachers' "Yes" (1) or "No" (0) responses regarding whether or not teachers have (1) a full certification or license, (2) a major in mathematics, and (3) a major in mathematics education. For teaching experience, mathematics teachers were asked, "By the end of this school year, how many years

will you have been teaching altogether?" and the teachers reported the number of years, which were recorded as: 0 = *none to 2 years*, 1 = *3 or more years*.

To measure the national-level gap in students' access to qualified teachers (research question 2), we developed five variables based on the difference between the percentage of high-SES students (standard deviation of 1 or higher) and the percentage of low-SES students (standard deviation of −1 or lower) who were taught by qualified teachers based on the five teacher-qualification variables listed above. The measure of the SES of students was created based on the education level of their parents, the existence of educational resources at home (calculator, computer, study desk or table, dictionary, and Internet connection), and the number of books at home. It was standardized around the mean in each nation.

For our last research question, we conducted multiple regression analysis to examine the relationships between (a) students' access to qualified teachers and national achievement and (b) the gap in students' access to qualified teachers and the achievement gap, controlling for educational expenditure as percentage of gross domestic product (GDP) and GDP per capita. For student achievement measures, we developed two national-level variables: (a) the national mean mathematics achievement of eighth graders and (b) the achievement gap measured by the difference in the mean mathematics score between high-SES students (standard deviation of 1 or higher) and low-SES students (standard deviation of −1 or lower). Educational expenditure as a percentage of GDP and GDP per capita was collected from the (UNESCO Institute for Statistics, n.d.). The data from 2007 were collected to match the TIMSS 2007 data. For the countries without 2007 data, the data from the closest year were used. The educational expenditure as a percentage of GDP varied from 2.1 % in Qatar to 8.0 % in Botswana, with a mean of 4.6 % and a standard deviation of 1.3. The GDP per capita in US$ 1,000 ranged from 1.4 (US$ 1,400) in Ghana to 77.4 (US$ 77,400) in Qatar, with a mean of 21.1 and a standard deviation of 16.9. Due to the complex sample design in TIMSS, this study used the International Database Analyzer software (version 2.0), developed by the IEA Data Processing and Research Center, and used appropriate sampling weights and replicate weights for the Jackknife Repeated Replication method in all the data analyses.

Results

National Achievement and Achievement Gap in Eighth-Grade Mathematics

We first examined the levels of national achievement and achievement gap based on eighth-graders' mathematics scores in the TIMSS 2007. Figure 3.1 presents the national mean mathematics achievement of eighth graders in 50 countries, with the size of the achievement gap represented in the vertical lines attached to the

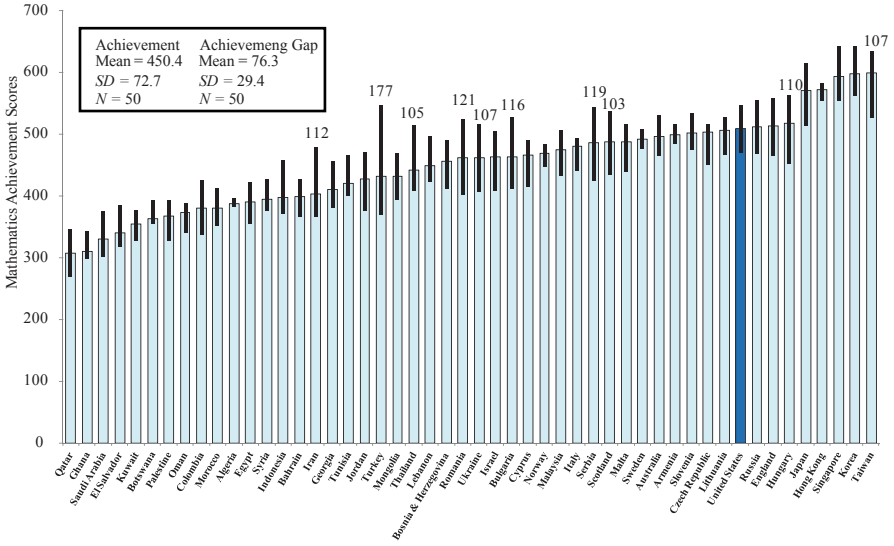

Fig. 3.1 Comparison of mathematics achievement scores and the achievement gap in 50 countries in 2007. (Note. The line attached to each bar represents the size of the achievement gap measured by the difference in mean achievement between students of high and low socioeconomic status. The ten countries with the largest achievement gaps have numbers above their bars showing the size of the gaps. Data are from the 2007 Trends in International Mathematics and Science Study [TIMSS] mathematics assessment).

bar graphs. The USA is highlighted in the graph, and 10 countries with the highest achievement gap are indicated with the size of the gap attached to the vertical lines. Among the 50 countries, the USA is ranked ninth in national achievement and 21st in the size of the achievement gap. National achievement scores varied from 307 in Qatar to 598 in Taiwan. Eighth graders in USA scored 509 on average, higher than the international average of 450. Although the US eighth graders' achievement was higher than the international average, the achievement gap between high-SES and low-SES students was similar to the international average (78 vs. 76). Algeria showed the smallest achievement gap (14), and Turkey showed the largest (177).

We can see from the figure that both high-achieving countries (e.g., Taiwan and Hungary) and low-achieving countries (e.g., Iran) produce large achievement gaps between high-SES and low-SES students. The Pearson correlation coefficient (r) for the relationship between national achievement and the achievement gap was 0.20 and not statistically significant ($p = 0.20$). This means that high-achieving countries do not necessarily produce a smaller achievement gap between high- and low-SES students.

National Level of Students' Access to Qualified Teachers

How does the percentage of eighth graders taught by qualified mathematics teachers in the USA differ from that in other countries? Table 3.1 shows the percentage ranking from the highest to the lowest in the percentage of students taught by teachers with each of the four qualifications (full certification, mathematics major, mathematics education major, and teachers with 3 or more years of teaching experience), as well as the percentage of students taught by teachers with full certification, mathematics major or mathematics education major, and 3 or more years of teaching experience. In the USA, 96.6% of eighth graders are taught by fully certified teachers, which is higher than the international average of 91.4%. In Iran, Japan, Korea, Malaysia, and Scotland, all students were taught by fully certified mathematics teachers. In these five countries, it is likely that strict government regulations prevent teachers from entering the teaching profession without certification, although the requirements for certification may differ across countries. In contrast, only 62.5% of students in Algeria and 55.8% of students in Morocco were taught by fully certified teachers.

When we look at mathematics major, only 42.4% of US students are taught mathematics by teachers with a major in mathematics, a smaller percentage than the international mean of 70.1%. The USA ranked 46th among 50 countries in this indicator of teacher qualification. The data suggest that, in a majority of countries, unlike in the USA, possession of a mathematics degree is a common characteristic of teachers teaching mathematics to eighth graders. Cross-nationally, the percentage varies from only 8.8% in Slovenia to 98.5% in Russia.

In the USA, a higher percentage of eighth graders are taught by teachers with a mathematics education major who received both subject content and pedagogical preparation. The data show that 48.5% of US eighth graders are taught by teachers with a mathematics education major, and the USA is ranked the 29th among 48 countries. The cross-national average is 53.8%, which indicates that having majored in *mathematics education* is a less common characteristic among teachers teaching mathematics than is having majored in *mathematics* in many countries. Here, we see a major cross-national variation ranging from 4.5% in Thailand to 95.7% in Hungary. These percentages in the USA indicate that a significant proportion of US eighth graders were taught mathematics by teachers without a subject-specific major.

Teaching experience is another indicator of teacher qualification associated with higher student achievement in the USA; 88.6% of US eighth graders were taught by teachers with 3 or more years of teaching experience, a figure similar to the international average of 90.7%. Cross-nationally, over 70% of eighth graders are taught by experienced teachers with 3 or more years of experience; this percentage ranged from 71.4% in Singapore to 99.5% in Georgia.

We also created an overall measure of students' access to *qualified teachers*, defined by those who have a full certification, mathematics major or mathematics education major, and 3 or more years of teaching experience. On average, in the

Table 3.1 Students' access to qualified teachers: percentage of students taught by qualified teachers

	Certified teachers[a]	%		Teachers with a math major	%		Teachers with a math education major[b]	%		Teachers with 3+years' experience	%		Overall teacher quality	%
1	Iran	100	1	Russia	98.5	1	Hungary	95.7	1	Georgia	99.5	1	Russia	96.7
1	Japan	100	2	Armenia	98.0	2	Slovenia	94.1	2	Russia	99.0	2	Armenia	94.0
1	Korea	100	3	Mongolia	97.1	3	Armenia	90.8	3	Bulgaria	98.9	3	Lithuania	92.6
1	Malaysia	100	4	Romania	96.7	4	Czech Republic	85.3	4	Egypt	98.5	4	Romania	89.8
1	Scotland	100	5	Hungary	96.6	5	Georgia	78.1	5	Kuwait	98.2	5	Ukraine	89.6
6	Botswana	99.9	6	Cyprus	96.3	6	Malta	75.5	6	Armenia	97.9	6	Bosnia & Herzegovina	88.7
7	Russia	99.7	7	Bulgaria	96.0	7	Indonesia	74.8	7	Algeria	97.8	7	Bulgaria	87.8
8	Cyprus	99.4	8	Bosnia & Herzegovina	95.9	8	Bulgaria	73.6	8	Iran	97.8	8	Czech Republic	87.2
8	Norway	99.4	9	Serbia	94.8	9	Bahrain	72.9	9	Lithuania	97.7	9	Iran	84.9
10	Turkey	99.3	10	Lithuania	93.5	10	Oman	72.6	10	Colombia	97.6	10	Georgia	83.4
10	Bulgaria	99.3	11	Tunisia	92.2	11	Egypt	71.2	11	Hungary	97.5	11	Israel	82.2
12	Bosnia & Herzegovina	98.6	12	Syria	91.9	12	Russia	70.4	12	El Salvador	96.5	11	Slovenia	82.2
13	Taiwan	98.4	13	Scotland	87.2	13	Korea	69.9	13	Ukraine	96.4	13	Cyprus	82.1
13	Ukraine	98.4	14	Morocco	86.6	14	Turkey	68.8	14	Bosnia & Herzegovina	96.3	14	Bahrain	81.9
15	Romania	98.3	15	Jordan	86.3	15	Qatar	65.3	14	Israel	96.3	15	Serbia	81.2
16	Singapore	98.2	16	Algeria	85.3	15	Romania	65.3	16	Czech Republic	95.9	16	Korea	78.9
17	Thailand	98.1	17	Taiwan	80.7	17	Sweden	63.3	17	Romania	95.5	17	Scotland	77.8
18	England	97.9	18	Colombia	79.1	18	Botswana	61.4	18	Italy	95.0	18	Malta	75.7
18	Israel	97.9	19	Palestine	77.9	19	Kuwait	61.0	19	Bahrain	94.4	19	Indonesia	75.6
18	Lithuania	97.9	20	Lebanon	77.0	20	Ukraine	58.7	20	Norway	94.0	20	Botswana	75.1
21	Bahrain	97.8	21	Israel	76.4	21	Colombia	57.9	21	Qatar	93.5	21	Japan	73.0
22	Hong Kong	97.4	22	Japan	76.3	22	Hong Kong	57.6	21	Indonesia	93.5	22	Turkey	71.4
23	*USA*	*96.6*	23	Botswana	73.3	23	Iran	57.3	23	Sweden	92.7	23	Qatar	70.7
24	Czech Republic	96.5	24	England	72.3	23	Israel	57.3	24	Slovenia	92.5	24	Taiwan	70.1
24	Australia	96.5	25	Thailand	72.1	25	Ghana	56.8	25	Morocco	92.3	25	Kuwait	67.5
26	Armenia	96.0	26	Oman	71.2	26	Japan	51.6	26	Malaysia	92.2	26	Mongolia	67.3

Table 3.1 (continued)

	Certified teachers[a]	%		Teachers with a math major	%		Teachers with a math education major[b]	%		Teachers with 3+years' experience	%		Overall teacher quality	%
27	El Salvador	95.3	27	Malta	70.7	27	Taiwan	50.3	27	Serbia	91.8	27	Syria	66.3
28	Sweden	94.9	28	Qatar	70.1	28	Singapore	48.7	28	Tunisia	91.1	28	El Salvador	63.2
29	Malta	94.2	29	Saudi Arabia	69.9	*29*	*USA*	*48.5*	29	Mongolia	90.7	28	England	63.2
30	Georgia	93.9	30	Ghana	68.9	30	Palestine	47.1	30	Lebanon	90.4	30	Sweden	61.6
31	Oman	92.7	31	Singapore	68.8	31	Scotland	46.5	31	Cyprus	89.0	30	Jordan	61.6
32	Indonesia	91.1	32	El Salvador	66.2	32	Australia	45.7	32	Taiwan	88.7	32	Oman	61.5
33	Slovenia	90.9	33	Egypt	63.0	33	El Salvador	45.6	*33*	*USA*	*88.6*	33	Egypt	61.4
34	Qatar	89.3	34	Bahrain	62.4	34	Malaysia	44.7	34	Korea	88.3	34	Thailand	60.7
35	Mongolia	86.6	35	Czech Republic	62.3	35	Jordan	44.1	35	Malta	87.7	35	Tunisia	60.4
36	Tunisia	85.6	36	Hong Kong	61.9	36	Saudi Arabia	42.8	36	Australia	87.6	35	Malaysia	60.4
37	Serbia	84.6	37	Kuwait	61.6	37	Serbia	41.4	36	Scotland	87.6	*37*	*USA*	*60.2*
38	Kuwait	83.6	38	Iran	57.5	38	Lebanon	40.4	38	Japan	87.3	38	Hong Kong	57.2
39	Italy	83.3	39	Ukraine	52.6	39	England	39.0	39	Syria	87.0	39	Singapore	57.1
40	Syria	82.6	40	Sweden	49.5	40	Bosnia & Herzegovina	36.5	40	Saudi Arabia	85.7	40	Australia	52.2
41	Egypt	80.1	40	Turkey	49.5	41	Lithuania	32.7	41	Jordan	84.5	41	Ghana	48.4
42	Jordan	78.9	42	Australia	49.2	42	Cyprus	27.5	42	Thailand	83.8	42	Lebanon	45.0
43	Ghana	75.7	43	Malaysia	46.2	43	Morocco	26.6	43	England	83.1	43	Algeria	44.5
44	Lebanon	71.1	44	Georgia	46.1	44	Algeria	25.9	44	Botswana	82.2	44	Palestine	44.4
45	Palestine	63.7	45	Indonesia	44.1	45	Syria	17.4	44	Palestine	82.2	45	Morocco	36.2
46	Algeria	62.5	*46*	*USA*	*42.4*	46	Tunisia	12.6	46	Turkey	81.5	46	Norway	35.8
47	Morocco	55.8	47	Norway	40.6	47	Norway	7.8	47	Hong Kong	81.3	47	Italy	14.6
			48	Korea	27.7	48	Thailand	4.5	48	Ghana	73.6			
			49	Italy	15.8				49	Oman	71.5			
			50	Slovenia	8.8				50	Singapore	71.4			
	Mean	*91.4*		*Mean*	*70.1*		*Mean*	*53.8*		*Mean*	*90.7*		*Mean*	*68.6*
	SD	11.0		*SD*	21.8		*SD*	21.5		*SD*	7.1		*SD*	17.4

[a] Data on certification were not available from Colombia, Hungary, and Saudi Arabia

[b] Data on mathematics education major were not available from Italy and Mongolia

47 countries, 68.6% of eighth graders were taught by teachers with these qualifications, and it ranged from only 14.6% in Italy to 96.7% in Russia. In the USA, 60.2% of eighth graders are taught by qualified teachers, and this figure is lower than the international average. The USA is ranked 37th in the level of students' access to qualified teachers.

National Level of Gap in Students' Access to Qualified Teachers

How does students' access to qualified teachers vary by their SES? Table 3.2 presents the difference in the percentage of high-SES students and low-SES students who were taught by qualified teachers. For the countries with a positive value of the percentage difference, high-SES students have a greater opportunity to be taught by qualified teachers than do low-SES students, indicating the existence of unequal access to qualified teachers and a greater gap. For countries with a negative value for the percentage difference, low-SES students were more likely than high-SES students to be taught by qualified teachers, indicating the existence of needs-based access to qualified teachers and a smaller inequality.[2]

When we look at the international average of 50 countries across all the indicators of teacher qualification, the gap is no more than 4%. On average, many countries are successful in equalizing access to qualified teachers along the line of SES. However, we can also observe a major variation across the countries in the size of gap in students' access to qualified teachers.

For students' access to fully certified teachers, the percentage gap varied from −13.7 in El Salvador to 11.1 in Algeria. In El Salvador, low-SES students had greater access to certified teachers than did high-SES students, whereas in Algeria, high-SES students had greater access to certified teachers than did low-SES students. In the USA, the difference was −2.0, showing that there is no major difference between high-SES and low-SES students in their access to certified teachers.

When we look at the difference in students' access to teachers with a mathematics major and mathematics education major between high-SES and low-SES students, the data showed larger variations across countries. The difference varied from −14.5 in Tunisia to 20.8 in Malaysia for mathematics major and from −18.3 in Algeria to 23.4 in Israel for mathematics education major. In the USA, the gap was 0% (41.0 vs. 41.0%) in mathematics major and 10.3% (53.3 vs. 43.0%) in mathematics education major, compared with the international average of 2.1 and 0.9%. This shows that US eighth graders have equal access to teachers with a major in mathematics, but high-SES students are more likely than low-SES students to

[2]Readers could argue that when low-SES students have greater access to qualified teachers than do high-SES students, high-SES students receive an unequal opportunity to be taught by qualified teachers. However, such a gap is likely the result of a government policy or system that attempts to promote greater equality in students' opportunity to learn, based on the preexisting disadvantage of low-SES students as compared with high-SES students. Therefore, we consider the inequality to be smaller in a national context where low-SES students have greater access to qualified teachers.

Table 3.2 Gap in students' access to qualified teachers: difference between high- and low-SES students in percentage of students taught by qualified teachers

	Certified teachers[a]	%		Teachers a with math major	%		Teachers with a math education major[b]	%		Teachers with>=3 years of experience	%		Overall teacher quality	%
1	Algeria	11.1	1	Malaysia	20.8	1	Israel	23.4	1	Turkey	26.8	1	Turkey	26.7
2	Serbia	10.5	2	El Salvador	11.9	2	El Salvador	17.9	2	Tunisia	14.5	2	Lebanon	17.0
3	Jordan	9.0	3	Oman	10.7	3	Cyprus	12.7	3	Malaysia	14.4	3	Mongolia	12.7
4	Indonesia	7.1	4	Colombia	10.6	4	Jordan	11.3	4	Mongolia	13.0	4	Algeria	12.1
5	Lebanon	6.7	5	Turkey	10.5	5	*USA*	*10.3*	5	Serbia	11.7	5	Malaysia	12.0
6	Syria	6.6	6	Serbia	9.7	6	Ghana	9.9	6	Ghana	11.4	6	Serbia	10.9
7	Mongolia	5.7	7	Italy	9.6	7	Singapore	9.8	7	Jordan	9.8	7	Indonesia	10.7
8	Qatar	5.4	8	Norway	9.1	8	Hong Kong	8.0	8	Saudi Arabia	9.6	8	Syria	10.6
9	Romania	5.2	9	Thailand	8.0	9	Romania	7.3	9	Romania	9.0	9	Bulgaria	9.7
10	Malta	4.4	10	Syria	7.8	10	Botswana	6.7	*10*	*USA*	*7.7*	10	Italy	9.6
11	Bosnia & Herzegovina	3.4	11	Indonesia	7.7	11	Japan	6.3	11	Syria	6.6	11	Taiwan	8.8
11	Lithuania	3.4	12	Qatar	7.3	12	Indonesia	6.1	12	Cyprus	6.3	12	Bosnia & Herzegovina	8.3
13	Singapore	3.1	13	Bulgaria	6.5	13	Taiwan	5.4	13	Malta	6.2	13	Romania	7.9
14	Italy	2.7	14	Egypt	6.2	14	Czech Republic	5.3	13	Lebanon	5.2	*14*	*USA*	*7.8*
15	Czech Republic	2.6	14	Taiwan	6.2	15	Scotland	3.7	15	Indonesia	4.9	15	Jordan	7.7
16	Hong Kong	2.5	16	Lebanon	5.9	15	Palestine	3.7	15	Palestine	4.9	15	Bahrain	7.7
17	Bahrain	1.8	17	Algeria	5.4	17	Colombia	3.6	17	Iran	4.3	17	Norway	7.6
18	Ukraine	0.8	18	Romania	4.9	18	Australia	2.9	18	Bosnia & Herzegovina	4.2	18	Thailand	7.1
19	Norway	0.7	19	Singapore	4.3	19	Oman	1.7	19	Singapore	3.0	19	England	6.9
19	Turkey	0.7	19	Hong Kong	4.3	20	Saudi Arabia	1.6	20	Slovenia	2.9	19	Singapore	6.9
19	Kuwait	0.7	21	Ukraine	4.0	21	Sweden	1.5	21	Korea	2.6	21	Iran	5.4
22	Cyprus	0.6	22	Bosnia & Herze-govina	3.7	22	Russia	0.7	22	Bulgaria	2.2	22	El Salvador	4.8

Table 3.2 (continued)

	Certified teachers[a]	%		Teachers a with math major	%		Teachers with a math education major[b]	%		Teachers with>=3 years of experience	%		Overall teacher quality	%
23	Palestine	0.5	22	Georgia	3.7	23	Armenia	0.5	23	Hungary	1.9	23	Egypt	3.4
24	Bulgaria	0.3	22	Slovenia	3.7	24	Bahrain	0.4	23	Sweden	1.9	24	Qatar	2.7
25	Taiwan	0.2	25	Australia	3.0	25	Iran	0.0	25	Algeria	1.6	25	Sweden	2.6
26	Oman	0.0	26	Mongolia	2.4	26	Hungary	−0.3	26	Botswana	1.4	26	Cyprus	2.2
26	Armenia	0.0	27	Ghana	1.7	27	England	−0.8	27	Ukraine	1.1	27	Hong Kong	1.6
26	Iran	0.0	28	Russia	1.1	28	Kuwait	−1.1	28	Bahrain	1.0	28	Ghana	1.5
26	Japan	0.0	29	Sweden	1.0	29	Thailand	−1.4	28	Israel	1.0	29	Scotland	0.9
26	Korea	0.0	30	Korea	0.9	30	Norway	−1.7	30	Thailand	0.9	30	Slovenia	0.9
26	Malaysia	0.0	31	Hungary	0.7	31	Syria	−1.8	31	Scotland	0.8	31	Israel	0.7
26	Scotland	0.0	32	Iran	0.1	32	Slovenia	−2.2	32	Egypt	0.7	32	Russia	0.3
26	Slovenia	0.0	*33*	*USA*	*0.0*	32	Lithuania	−2.2	33	Czech Republic	0.5	33	Malta	0.2
34	Russia	−0.3	33	Cyprus	0.0	34	Korea	−3.0	34	Taiwan	−0.3	34	Czech Republic	0.1
35	Georgia	−0.6	35	Palestine	−0.3	34	Bulgaria	−3.0	35	Russia	−0.8	35	Australia	−0.3
36	Botswana	−0.7	36	Armenia	−0.5	36	Tunisia	−3.3	36	Lithuania	−1.2	36	Lithuania	−0.4
37	England	−1.0	37	Scotland	−0.8	37	Turkey	−4.2	37	Qatar	−1.6	37	Ukraine	−0.7
38	Sweden	−1.5	38	England	−1.2	38	Egypt	−4.4	37	Kuwait	−1.6	38	Korea	−2.4
38	Egypt	−1.5	39	Botswana	−2.1	39	Ukraine	−4.7	39	El Salvador	−2.1	39	Botswana	−2.5
40	*USA*	*−2.0*	39	Lithuania	−2.1	40	Lebanon	−4.8	40	Georgia	−2.2	40	Armenia	−2.8
41	Israel	−2.2	41	Japan	−3.4	41	Serbia	−5.4	41	Armenia	−2.8	41	Oman	−3.1
42	Thailand	−2.9	42	Bahrain	−4.0	42	Georgia	−6.2	42	Colombia	−2.9	42	Palestine	−3.5
43	Australia	−4.2	43	Saudi Arabia	−4.7	43	Bosnia & Herzegovina	−7.3	43	England	−3.0	43	Japan	−4.2
44	Ghana	−7.0	44	Czech Republic	−4.9	43	Morocco	−7.3	44	Australia	−3.1	44	Morocco	−5.5
45	Morocco	−9.8	45	Israel	−7.3	45	Malaysia	−10.9	45	Norway	−4.1	45	Georgia	−6.3
46	Tunisia	−12.8	46	Kuwait	−9.1	46	Qatar	−11.5	45	Italy	−4.1	46	Kuwait	−6.9
47	El Salvador	−13.7	47	Morocco	−9.7	47	Malta	−13.8	47	Oman	−4.8	47	Tunisia	−9.6
			48	Jordan	−10.6	48	Algeria	−18.3	48	Hong Kong	−6.0			
			49	Malta	−11.2				49	Japan	−6.1			
			50	Tunisia	−14.5				50	Morocco	−6.7			
	Mean	*0.7*		*M*	*2.1*		*M*	0.9		*M*	*2.8*		*M*	*4.0*
	SD	5.0		*SD*	6.8		*SD*	7.8		*SD*	6.4		*SD*	6.9

[a] Data on certification were not available from Colombia, Hungary, and Saudi Arabia

[b] Data on mathematics education major were not available from Italy and Mongolia

Table 3.3 Comparison of students' access to qualified teachers and gap in access in 2003 and 2007 in the USA

		2003[a]	2007
Percentage of students taught by qualified teachers	Certified teachers	95.4	96.6
	Teachers with math major	47.3	42.4
	Teachers with math education major	55.3	48.5
	Teachers with 3 + years experience	90.8	88.6
	Overall teacher qualification	*60.3*	*60.2*
Gap in percentage of students taught by qualified teachers	Certified teachers	1.8 (96.0 vs. 94.2)	−2.0 (95.4 vs. 97.4)
	Teachers with math major	10.0 (54.1 vs. 44.1)	0.0 (41.1 vs. 41.1)
	Teachers with math education major	13.8 (59.9 vs. 46.1)	10.3 (53.3 vs. 43.0)
	Teachers with 3 + years experience	3.6 (93.8 vs. 90.2)	7.7 (92.2 vs. 84.5)
	Overall teacher qualification	*14.4* (67.6 vs. 53.2)	*7.8* (63.5 vs. 55.7)

[a] Figures are from Akiba et al. (2007)

Overall teacher qualification was measured by having a full certification, having majored in mathematics or mathematics education, and having 3 or more years of teaching experience

be taught by teachers with a mathematics education major. The gap in students' access to teachers with at least 3 years of teaching experience varied from −6.7% in Morocco to 26.8% in Turkey. In the USA, the gap was 7.7%, with 63.5% of high-SES students and 55.7% of low-SES students taught by experienced teachers. This figure was larger than the international average of 2.8%.

In the overall measure of teacher qualification, 63.5% of high-SES students in the USA were taught by teachers with certification, mathematics or mathematics education major, and at least 3 years of teaching experience compared with 55.7% of low-SES students, with a gap of 7.8%. This is larger than the international average of 4.0%. The size of gap varied from −9.6 in Tunisia to 26.7 in Turkey. In 13 countries, including Tunisia, Kuwait, Japan, and Australia, low-SES students have a greater opportunity to be taught by qualified teachers than do high-SES students.

Improvement from 2003 to 2007 in Students' Access to Qualified Teachers and Gap in the Access

The NCLB Act of 2001 required states to ensure that all students are taught by highly qualified teachers by the 2005–2006 academic year. If the NCLB influenced state policy, we are likely to see improvement in students' access to qualified teachers, as well as equalization of such access between low-SES and high-SES students from 2003 to 2007. Table 3.3 compares the figures in 2003, obtained by Akiba et al. (2007) using the same measures of teacher qualification, and the figures in 2007.

We can see that the percentages of students taught by certified teachers and teachers with 3 or more years of teaching experiences did not change much from 2003 to 2007, but the percentages of students who were taught by teachers with a mathematics major or mathematics education major decreased from 47.3 to 42.4% and from 55.3 to 48.5%, respectively. This is a surprising finding considering the focus on the requirement of subject-matter knowledge in highly qualified teachers in the NCLB. It may be due to the fact that most states required teachers to pass a subject-specific test (Praxis II assessment) to meet the subject knowledge requirement rather than requiring a subject area major. Evaluation studies have indeed found that although all states had administered tests of teacher content knowledge (Birman et al. 2009), only 26 states required teachers to have a major in the subject area they teach as of the 2005–2006 academic year (Loeb et al. 2009). The percentage of students taught by teachers who are fully certified, who have majored in mathematics or mathematics education, and who have had 3 or more years of teaching experience remained the same: 60.3% in 2003 and 60.2% in 2007.

The gap in access to qualified teachers between high-SES and low-SES students, however, showed a major improvement. The difference in students' access to qualified teachers between high-SES and low-SES students narrowed from 14.4% (67.6 vs. 53.2%) in 2003 to 7.8% (63.5 vs. 55.7%) in 2007. Although the gap in students' access to experienced teachers became larger (from 3.6 to 7.7%), the gap in access to teachers with a mathematics major disappeared (from 10 to 0%), and the gap in access to teachers with fully certified teachers and teachers with a mathematics education major was narrowed (from 1.8% to −2.0% and from 13.8 to 10.3%, respectively). The major reduction of the gap in students' access to teachers with a major in mathematics may be due to the increased number of alternatively certified teachers with a major in mathematics in low-SES schools. In order to meet the requirement of highly qualified teachers, many states allowed the establishment of alternative certification programs, which recruit those with strong subject content knowledge (e.g., working professionals in mathematics and science fields and those with mathematics majors) to become mathematics teachers (Loeb and Miller 2006). Many federal programs required teacher candidates to work in high-needs schools (low-SES, low-achieving schools) in exchange for fully supporting the cost for pursing alternative certification (e.g., National Science Foundation Noyce Grant). The number of teachers certified through alternative routes dramatically increased from 38,519 in 2003 to 62,000 in 2007 (Feistritzer 2010). It is likely that distribution of alternatively certified teachers to low-SES schools has contributed to narrowing the gap in students' access to teachers with a major in mathematics.

Students' Access to Qualified Teachers, Access Gap, and National Achievement Outcomes

For our last research question, we conducted multiple regression analyses to examine the relationships between (a) students' access to qualified teachers and na-

Table 3.4 Multivariate relationship between students' access to qualified teachers and national achievement

National predictors	Model 1 B (*SE*)	Model 2 B (*SE*)	Model 3 B (*SE*)	Model 4 B (*SE*)	Model 5 B (*SE*)
Teacher qualification					
Teacher certification	2.94 (1.08)*				
Math major		−0.07 (0.50)			
Math education major			0.35 (0.54)		
Teaching experience				−0.06 (1.50)	
Overall teacher qualification					0.81 (0.63)
National variables					
Educational expenditure as % of GDP	0.53 (7.29)	−0.24 (7.91)	1.62 (8.53)	−0.33 (7.96)	2.57 (7.82)
GDP per capita (US$ 1,000)	0.57 (0.59)	1.04 (0.65)	1.07(0.64)	1.07 (0.63)	1.18 (0.61)
R^2	0.22	0.07	0.07	0.07	0.11
N	43	46	46	46	43

B unstandardized regression coefficient, *GDP* gross domestic product, R^2 percentage of variance in the dependent variable explained by the independent variables
*$p<0.05$; **$p<0.01$

tional achievement and (b) the gap in students' access to qualified teachers and the achievement gap controlling for educational expenditure as a percentage of GDP and GDP per capita.

Tables 3.4 and 3.5 present five multiple regression models with each of the teacher qualification indicators. The sample size varied from 43 to 46 because of the unavailability of data on educational expenditure as percentage of GDP and/or GDP per capita in some countries. Table 3.4 shows that the percentage of students taught by certified teachers was associated with national achievement. Countries where a higher percentage of eighth graders was taught by certified teachers achieved higher mathematics scores than did other countries. However, no other teacher qualification indicators including the overall measure of teacher qualification showed a statistically significant relationship with national achievement in mathematics.

In contrast, Table 3.5 shows that the level of the gap measured by the difference in the percentages of high-SES students and low-SES students taught by teachers with multiple qualifications (full certification, mathematics major or mathematics education major, and 3 or more years of teaching experience) was associated with the national level of achievement gap between high-SES and low-SES students in mathematics. In countries where there is a larger gap in students' access to qualified mathematics teachers, the size of the achievement gap in mathematics tends to be larger. When these qualification indicators were examined individually, however, only the gap in students' access to experienced teachers was associated with the achievement gap. This means that inequality in students' access to qualified teachers can be more detrimental when we consider multiple qualifications than when we consider individual qualifications separately. This hypothesis makes sense because teachers who have multiple qualifications are more likely to practice effective instruction than are teachers with only a certification or a major in mathematics.

Table 3.5 Multivariate relationship between gap in students' access to qualified teachers and achievement gap (high-SES vs. low-SES students)

National predictors	Model 1	Model 2	Model 3	Model 4	Model 5
	B (*SE*)	B (*SE*)	B (*SE*)	B (*SE*)	B (*SE*)
Opportunity gap					
Teacher certification	1.06 (0.94)				
Math major		0.19 (0.66)			
Math education major			−0.09 (0.60)		
Teaching experience				2.12 (0.60)**	
Overall teacher qualification					1.83 (0.61)**
National variables					
Educational expenditure as % of GDP	−3.69 (3.38)	−3.82 (3.50)	−4.25 (3.28)	−5.63 (2.84)	−2.08 (3.12)
GDP per capita (US$ 1,000)	−0.35 (0.25)	−0.32 (0.25)	−0.32 (0.26)	−0.06 (0.23)	−0.23 (0.23)
R^2	0.11	0.08	0.08	0.28	0.25
N	43	46	44	46	43

B unstandardized regression coefficient, *GDP* gross domestic product, R^2 percentage of variance in the dependent variable explained by the independent variables
*$p<0.05$; **$p<0.01$

Discussion

This cross-national study of 50 countries investigated an important focus of educational reforms around the world: students' access to qualified teachers and inequality in such access based on student SES. Based on the TIMSS mathematics assessment for eighth graders, the study found that the US students scored more than the international average (509 vs. 450), but the size of the achievement gap was similar to the international average (78 vs. 76). Akiba et al. (2007) reported that US eighth-graders' national achievement level was 504, and their achievement gap was 109 in 2003. This means that whereas the national achievement level has remained stable, the level of the achievement gap based on the TIMSS mathematics assessment for eighth graders has narrowed significantly.

This pattern coincided with the national level of students' access to qualified teachers and the gap in such access between high-SES and low-SES students. The percentage of students who were taught by qualified teachers did not change much from 2003 (60.3) to 2007 (60.2), but the difference in the percentage of students taught by qualified teachers between high-SES and low-SES students narrowed from 14.4 to 7.8%. Reduced levels of achievement gap and inequality in access to qualified teachers between high-SES and low-SES students are great news, showing the progress toward equalizing students' opportunity to learn in the USA. However, it is also important to keep in mind that about 40% of the students do not have access to qualified mathematics teachers with a full certification, a mathematics major or mathematics education major, and three or more years of teaching experience. This is larger than the international average of 31.4% (100–68.6%) among 47 countries. Even though the gap in students' access to qualified teachers was nar-

rowed from 2003 to 2007, in 2007 only 55.7% of low-SES students were taught by qualified teachers compared with 63.5% of high-SES students. This gap of 7.8% is still larger than the international mean of 4.0%. There is a need to continue with the efforts to increase students' access to qualified teachers and to continue narrowing the gap in such access among students.

Our cross-national analysis of the relationships between students' access to qualified teachers and national achievement showed that the countries with a higher percentage of students taught by qualified teachers are not necessarily producing high national achievement. This is different from the findings based on the 2003 TIMSS data (Akiba et al. 2007) that showed a relationship between students' access to qualified teachers and national achievement. It may be because of the differences in the countries that participated in 2003 and 2007. A total of 15 new countries participated in the 2007 TIMSS, and nine of these are developing countries with the GDP per capita of less than US$ 10,000 (compared with the mean of US$ 21,100 among 50 countries). Several of these countries, such as Bosnia, Herzegovina, Georgia, and Ukraine, have over an 80% national level of student access to qualified teachers; yet, their national achievement level is not among the highest. Future studies may examine the factors that mediate the relationship between teacher qualifications and student achievement in these countries.

The gap in students' access to qualified teachers between high-SES and low-SES students, however, was associated with the size of the achievement gap. Many countries with a large gap in students' access to qualified teachers, including Turkey, Serbia, Bulgaria, Taiwan, and Romania, also have a large achievement gap in mathematics assessment. In contrast, many countries where a larger percentage of low-SES students than high-SES students are taught by qualified teachers (e.g., Tunisia, Kuwait, Armenia, and Lithuania) produced a small achievement gap between these groups of students. It may be that in many of the countries that participated in the 2007 TIMSS, less qualified teachers receive less school resources and professional development opportunities than do more qualified teachers, which contributes to the gap in their instructional quality and to the achievement gap.

It is also important to note that there is no statistically significant relationship between students' access to qualified teachers and the gap in students' access to qualified teachers (Pearson $r=-0.14$, $p=0.34$), meaning that the countries where a larger percentage of students are taught by qualified teachers do not necessarily ensure equal access to qualified teachers between high-SES and low-SES students. This shows the difficulty in increasing the number of qualified teachers while making sure that students have equal access to these teachers.

A decentralized hiring system at the school or at the district level in the USA makes it challenging to ensure students' access to qualified teachers. Because of the different level of resources and teacher salary level across districts and schools, qualified teachers tend to concentrate in wealthier schools. However, federal involvement in alternative certification programs through providing funding to subsidize the cost of teacher education in mathematics and science areas in exchange for working in high-needs schools seems to have contributed to narrowing the gap in students' access to qualified teachers between high-SES and low-SES students from

2003 to 2007. This shows the promise of federal or state government's involvement in promoting students' equal access to qualified teachers.

Many countries around the world have centralized teacher hiring and distribution policies. For example, Australia has a state-level system to hire and distribute teachers using strong financial incentives (Akiba and LeTendre 2009). Teachers receive a higher salary, an extra bonus, and multiple benefits (e.g., housing subsidy, additional paid leave, and additional professional development leaves) for working in remote rural schools where teacher shortage is most severe. When the hiring system is centralized at the state level, it is possible to offer strong incentives to distribute qualified teachers to work in the schools where such teachers are most needed.

The USA faces a major challenge of increasing qualified teachers while ensuring students' equal access to qualified teachers in a highly decentralized system with a major variation in financial capacity across districts and schools. This financial disparity not only affects districts and schools' capacity to hire qualified teachers but also affects teachers' working conditions and professional development opportunities, which are critical for improving instructional quality. This study provides evidence that the countries that do not ensure students' equal opportunity to be taught by qualified teachers produce a larger achievement gap. The fact that there are many countries that succeeded in equalizing students' access to qualified teachers shows that such success depends on the political will to ensure students' right to be taught by qualified teachers regardless of their individual or home background. Further investigation of these countries with regard to how they achieved equity in students' access to qualified teachers is a fruitful area of study that can produce important policy-related information useful for the many countries that are struggling to achieve such equality.

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