Quality Assurance in Teacher Education and Outcomes: A Study of 17 Countries

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This study investigated the relationship between policies related to the recruitment, selection, preparation, and certification of new teachers and (a) the quality of future teachers as measured by their mathematics content and pedagogy content knowledge and (b) student achievement in mathematics at the national level. The study used data collected for the Teacher Education and Development Study in Mathematics, which compared the ways in which 17 countries prepared teachers of mathematics for the primary and secondary levels. A consistent positive association was found between the strength of a country's quality assurance arrangements and future teachers' knowledge of mathematics and mathematics pedagogy. Countries with strong policies for assuring the quality of new teachers were also found to be among the strongest performers on international tests of mathematics achievement.

Keywords: accreditation; case studies; certification/licensure; content analysis; correlational analysis; educational policy; mathematics education; policy analysis; secondary data analysis; teacher education/development

Investment in initial teacher preparation is clearly important, but there is little research to guide policymakers about how best to direct that investment to assure the quality of new teachers and sustained benefits for school systems. The purpose of this study was to investigate the relationship between the relative strength of a nation's quality assurance arrangements—policies and practices for assuring the quality of teacher education programs—and two outcomes: (a) the quality of future teachers as measured by their mathematics content and pedagogy content knowledge in the final stages of their preparation and (b) national-level student achievement in mathematics.

International interest in policies that promote teacher quality and quality teaching has increased markedly in recent years (Beauchamp, Clarke, Hulme, & Murray, 2013; Darling-Hammond & Bransford, 2005; European Commission, 2013; Mourshed, Chijioke, & Barber, 2010; Organisation for Economic Co-operation and Development [OECD], 2005, 2011, 2013; Tucker, 2012). As a consequence, many countries are focusing on teacher preparation and giving closer attention to policies that will attract, prepare, and graduate the best possible teachers (e.g., American Federation of Teachers, 2012; European Commission/EACEA/Eurydice, 2015; Feuer, Floden, Chudowsky, & Ahn, 2013; Schleicher, 2013, 2014).

Policies for assuring the quality of beginning teachers cover three main stages. The first stage comprises *recruitment and selection* policies to assure the quality of entrants to teacher education. These include policies to make teaching and teachers' work an attractive career option for high academic achievers, matching supply to demand, setting high prerequisite standards for admission to teacher education programs, and selecting only applicants who have already demonstrated high levels of academic achievement. The second includes *accreditation* policies and agencies to monitor and assure the quality of teacher education institutions and their programs. The third spans policies and agencies governing full *entry to the profession*, variously referred to as "certification," "licensing," or "registration" in different countries.

These are three key policy levers for quality assurance that apply to any professional preparation system, not just to teaching. However, research has shown that these levers are often weaker in teaching than in other professions (Ingvarson, Elliott, Kleinhenz, & McKenzie, 2006). Although many countries are developing policies to strengthen arrangements to assure the

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quality of teacher education programs and their future teachers, little is known about their relative impact on the quality of beginning teachers. Previous research described and compared the quality assurance arrangements in various countries (Eurydice, 2006; Ingersoll et al., 2007; Wang, Coleman, Coley, & Phelps, 2003), yet no international research has statistically examined the relationship between the relative strength of these quality assurance policies and the quality of future teachers using comparable and representative data. Nor have any studies examined whether the national student achievement level is related to the policies a country applies to assure the quality of its teacher education programs and their graduates.

There is also little research that informs policymakers to determine where best to place their emphasis: on recruitment, on the accreditation of teacher education providers, or on more rigorous licensing tests and entry standards. Where they place their emphasis can determine who is held accountable for the quality of new teachers. If the emphasis falls on the attractiveness of teaching as a career, the accountability spotlight is more likely to fall on governments and the salaries and working conditions of teachers relative to other professions. Governments may instead prefer to focus the accountability spotlight on teacher education providers, demanding more rigorous procedures for assessing and accrediting their programs. Or governments may demand that graduates undertake additional knowledge and performance assessments after they graduate during an induction, internship, or residency period and before they can gain certification and full entry to the teaching profession.

Heated arguments have been taking place in several countries about how to ensure high-quality graduates from teacher education programs (American Federation of Teachers, 2012; Barber & Mourshed 2007; Schleicher, 2012; Teacher Education Ministerial Advisory Group, 2014). These discussions would benefit from more rigorous international research about policies and practices that assure the quality of new teachers over the long term with sustained benefits for school systems. The Teacher Education and Development Study in Mathematics (TEDS-M), conducted in 2008 and sponsored by the International Association for the Evaluation of Educational Achievement (IEA), provided an opportunity to contribute to this debate by examining the relationship between quality assurance arrangements and teacher education outcomes in more depth.

The research questions addressed are as follows:

1. How substantial are the differences between countries in the strength of the quality assurance arrangements to ensure the quality of future teachers?
2. For programs preparing teachers to teach at comparable levels, are greater levels of mathematics content knowledge (MCK) and mathematics pedagogy content knowledge (MPCK) achieved in countries with stronger quality assurance arrangements in teacher education?
3. At the national level, do countries with stronger quality assurance arrangements achieve at higher levels on international tests of mathematics achievement (Trends in International Mathematics and Science Study [TIMSS] and Programme for International Student Assessment [PISA])?

Literature Review

Conceptualizing Quality Assurance Arrangements

Three reports significantly influenced the design of the study reported here, in particular, conceptualizing the strength of a nation's policies and agencies for assuring the quality of new teachers. Wang et al. (2003) at the Education Testing Service (ETS) compared the quality assurance arrangements in seven countries whose students had performed well on TIMSS 1999 (Australia, England, Hong Kong, Japan, Korea, Netherlands, and Singapore) with those in the United States. Ingersoll et al. (2007) conducted a similar study comparing the preparation requirements and standards for primary and secondary teachers in the United States with those in South Korea, China, Hong Kong Special Administrative Region (SAR), Singapore, Thailand, and Japan. In each of these studies, as in TEDS-M, the selection of countries was opportunistic rather than a result of any systematic sampling design. A third report commissioned by the European Commission, *Quality Assurance in Teacher Education in Europe* (Eurydice, 2006), was also useful in conceptualizing the main components of a quality assurance system.

Wang et al. (2003) conceptualized quality assurance arrangements as a sequence of "filters" along a pipeline from entry to certification and tenure. They identified eight filters in their "policy model of the teacher-supply pipeline," including policies affecting entrance to teacher education, the teacher education curriculum, completion of teacher education, entry-level certification, hiring, tenure and compensation, professional development, and advanced certification. Each was a point at which a country might exert pressure and control the flow of candidates. Countries differed markedly in where they exerted quality-control pressure. Most countries, such as Singapore, Japan, and the Netherlands, placed extra pressure ("high stakes") at the front end, setting high entry standards and limiting the numbers entering teacher education to the demand for new teachers. A few countries, such as England and the United States, had open entry policies ("low stakes") but exerted pressure by means of subject matter and performance tests ("high stakes") at the certification or tenure stage after graduation. The Wang et al. study provided a three-level rubric for classifying the various filters as high (dense), medium, or low (porous) stakes and measuring the relative strength of quality assurance systems, which guided the rubric developed for the present study.

The main finding in the Wang et al. (2003) report was that high-performing countries on TIMSS were consistently rigorous in applying the high-stakes filters across all stages in the pipeline, from recruitment to certification. High-performing countries, like Singapore and Korea, were more likely than the United States to "front load" their quality assurance requirements. However, as with the Ingersoll et al. (2007) study, the high-performing countries were not only selective about entrants to teacher education programs; they ensured that teaching had a strong pool of applicants from which to select in the first place. These countries made teaching a very attractive career choice for abler secondary school and university graduates, in terms of both salary and working conditions. Attrition rates were consequently low. Recruitment policies in these countries made it easier to ensure that the supply of new teachers matched the demand for high-quality graduates.

Ingersoll et al. (2007) conceptualized quality assurance arrangements slightly differently. They were interested in how each country defined a "qualified teacher" and how that country's quality assurance system ensured that all students were taught by qualified teachers. They focused at first on "requirements" in terms of educational qualification (i.e., degree earned) and in terms of professional qualification (i.e., certification). They found little variation in the educational qualifications or professional qualifications required across the seven countries. However, they did find dramatic differences between countries in the selectivity of programs and in the ability of teaching to compete successfully, in terms of salaries and working conditions, with other professions for academically successful entrants. Ingersoll et al. also documented major differences across countries in the extent to which teachers were teaching outside their field of certification—the fields in which they were educated and trained. They reported this problem as being severe in the United States, suggesting that the relative standing of the United States on international tests may be hindered by the extent of "out-of-field" teaching.

The Ingersoll et al. (2007) study indicated that policies focused on filters alone were unlikely to be effective unless accompanied by policies that ensured teachers' salaries and working conditions were commensurate with those of other professions competing for high-quality graduates. Based on this finding, the current study included policies and practices designed to assure the attractiveness of teaching as a career as part of the quality assurance system, such as salary levels relative to GDP per capita plus benefits, the status of teaching, and attractive working conditions (e.g., hours of face-to-face teaching).

A report commissioned by the European Commission (Eurydice, 2006) was useful in conceptualizing the accreditation component of a quality assurance system. The report provided a comprehensive summary of procedures for evaluating and accrediting initial and in-service teacher education at that time. The European Commission was interested in developing suitable indicators for measuring improvement in the education of teachers, as part of a more general objective of enhancing the quality and effectiveness of education and training systems in Europe by 2010. Of the 30 countries considered in the Eurydice report, most (24) had only general regulations for the evaluation of all higher education institutions in 2004. Few had accreditation systems specifically geared to the evaluation of teacher education institutions or programs.

The Eurydice (2006) report provided a useful way of classifying the strength of policies and procedures regarding the assessment and accreditation teacher education programs by external agencies. It drew attention to the importance of an independent accreditation authority and, for example, provided a comprehensive description of possible procedures that external evaluators might use in gathering evidence about a teacher education program during site visits.

Although these studies were useful in conceptualizing quality assurance arrangements, none had statistically examined the relationships between quality assurance policies and practices and the quality of graduates from teacher education programs. Wang et al. (2003) and Ingersoll et al. (2007) compared quality assurance arrangements in the United States with those in countries whose school students had performed well on TIMSS, but they did not gather data about the quality of future teachers. Nor did the Eurydice (2006) study examine relationships between accreditation arrangements and the outcomes of teacher education programs.

Quality Assurance Arrangements in Different Countries

This section reviews research studies related to each of the three key decision points in assuring the quality of beginning teachers: who gains entry to teacher education, who can provide teacher education programs, and who gains certification and full entry to the teaching profession.

Policies and practices to assure the quality of entrants to teacher education. Countries such as Canada, Chinese Taipei, Finland, and Singapore are well known as countries with effective recruitment policies at the national level (Barber & Mourshed, 2007). Their governments offer a profession with status and relatively attractive salaries, working conditions, and career prospects, ensuring a strong demand for teacher education places from their ablest high school graduates (Akiba, Chiu, Shimizu, & Liang, 2012; Hsieh, Ling, Chao, & Wang, 2013; Sahlberg, 2011; Wong et al., 2013).

Barber and Mourshed (2007) examined teacher quality policies in high-achieving countries based on the PISA results and reported that "the top-performing school systems we studied recruit their teachers from the top third of each cohort that graduate from their school systems; the top 5% in South Korea, the top 10% in Finland, the top 30% in Singapore" (p. 16).

Kang and Hong (2008) found that countries such as South Korea have both a high percentage of students taught by qualified teachers and equality of access to qualified teachers by students, no matter whether they are from high-socioeconomic or low-socioeconomic backgrounds. They claimed that South Korea's success in studies such as TIMSS 2003, relative to countries such as the United States, was related to the respect accorded to the teaching profession in South Korea, the working conditions (nearly half the number of face-to-face teaching hours per year), and relatively high salaries for experienced teachers.

Evidence about the importance of quality assurance policies to recruitment also comes indirectly from studies showing a relationship between a country's recruitment policies and the quality of entrants to its teacher education programs. Chevalier, Dolton, and McIntosh (2007), for example, demonstrated a clear relationship in England between changes in teacher salaries relative to other professions and the quality of university degrees (First, Second, and Third class) among applicants to teacher education programs. Schleicher (2013) reports that high-performing countries are more likely to focus educational policy directly on recruiting academically successful students and treating teachers as professionals. Research in Australia also shows that the lack of competitiveness of teacher salaries, relative to other professions, is the main factor turning potentially good teachers away from choosing teaching as a career (Department of Education, Science, and Training, 2006).

Recent research also indicates a relationship between recruitment policies, represented by investment in attractive salaries, and levels of student performance on international tests of

student achievement. Based on TIMSS data, Carnoy, Beteille, Brodziak, Loyalka, and Luschei (2009) found that countries paying teachers higher relative salaries had higher student achievement in mathematics. In their study of teacher pay and pupil performance (using PISA scores) across 39 countries, Dolton and Marcenaro-Gutierrez (2011) found that there was a "highly significant and positive effect of teacher wages (relative to GDP per capita) on pupil test scores" (p. 41). In a study across 30 countries, Akiba et al. (2012) showed it was not the salaries for beginning teachers that distinguished countries with higher student achievement—it was the amount and the ratio of salaries of experienced teachers relative to GDP per capita.

Policies and practices to assure the quality of teacher education programs. In contrast, recent policy initiatives in countries such as Australia, England, and the United States have focused more on processes for accrediting teacher education providers than on recruitment and increasing the attractiveness of a career in teaching. Policymakers have been calling for more rigorous methods of assessing and accrediting teacher education programs, especially in terms of measures of the quality of their graduates (Council for the Accreditation of Educator Preparation, 2013; Feuer et al., 2013; Furlong, 2013; Teacher Education Ministerial Advisory Group, 2014). There have also been moves in this direction in Europe (European Association for Quality Assurance in Higher Education, 2009). The OECD report *Teachers Matter* (OECD, 2005) drew attention to the concern in many countries that arrangements for assessing and accrediting teacher education institutions and programs were weak and had little impact on the quality of teacher education.

However, although there has been some research in the United States (Wilson & Youngs, 2005), there has been little international comparative research on accreditation or its relationship to the quality of graduates. As mentioned above, the Eurydice (2006) report provided a comprehensive description of procedures for accrediting initial teacher education in the mid-2000s but did not attempt to identify relationships between these procedures and the quality of teacher education programs.

Policies and practices for the certification of new teachers. Quality assurance policies can also, or instead, focus on the third stage beyond graduation, referred to variously as "licensing," "certification," or "registration" in different countries.

Policymakers can set a high bar to gaining full entry to the profession, in the hope that this will have effects that flow back to lift the quality of entrants and programs. These policies usually call for a period, variously called "internship" or "provisional certification," of one or more years, before new teachers can gain full entry to the profession. Chinese Taipei, England, and most states in Australia and the United States, for example, now require teacher education graduates to successfully complete further assessments during a period of provisional registration (or "residency" in some cases), before gaining full entry to the profession or tenure.

In Chinese Taipei, graduates face a rigorous set of assessments before they can gain a tenured teaching position (Hsieh et al., 2013). They must not only pass the Ministry of Education's Teacher Qualification Assessment to gain a teaching credential, but to gain a teaching position in a particular region, they must also undergo an onsite screening process consisting of two stages: (a) written tests designed to assess education professional knowledge or subject matter knowledge and (b) a demonstration of their teaching competency and a personal interview, both of which are evaluated by a panel of teachers and a principal. A recent Australian report called for more robust measures of standards-based performance (Teacher Education Ministerial Advisory Group, 2014). In the United States, most states require future teachers to meet additional requirements after earning an initial license and entering teaching (Youngs & Grogan, 2013). Increasingly, these requirements include successful completion of a portfolio documenting ability to meet teaching performance standards, such as the edTPA developed by the Stanford Center for Assessment, Learning (http://edtpa.aacte.org/).

There is little research, however, on the characteristics of effective schemes for the certification of new teachers, perhaps because teacher educators, policymakers, and the teaching profession have yet to reach agreement on what beginning teachers should know and be able to do. Wilson and Youngs (2005) reviewed research on the relationship between certification status (certified, uncertified, and undercertified) and teacher effectiveness. Of the eight studies reviewed, seven found positive correlations between certification and student achievement, which for most studies was based on mathematic achievement test scores. Most studies were based on experienced teachers, not future teachers as in TEDS-M. Wilson and Youngs identified difficulties in conducting reliable research in this area in the United States. There is considerable variation from state to state in approaches to certification and how consistently these are applied. They also called for broader measures of impact.

Akiba, LeTendre, and Scribner (2007) used Grade 8 mathematics assessment and teacher survey data from TIMSS 2003 to examine the relationship between the percentages of teachers with full certification and math or math education major as part of teacher quality measures and national achievement levels in mathematics. They found that the higher-achieving countries had greater proportions of students taught by teachers who had met their country's criteria for full certification and majoring in mathematics or mathematics education. Like Ingersoll et al. (2007), this study indicates that variation in mathematics achievement (within and between countries) may be related to policies regarding teachers' mathematics-specific qualifications requirements at every stage of teacher education, from entry to graduation, as well as requirements for certification. This finding is supported by studies showing links between teachers' knowledge of mathematics subject matter and how to teach it, and student achievement (e.g., Baumert et al., 2010; Goulding, Rowland, & Barber, 2002; Hill, Rowan, & Ball, 2005; Ma, 1999). Perhaps the main guide that can be taken from research so far is that beginning teachers of mathematics should have deep understanding of what they will be expected to teach before gaining certification.

This review found that although several studies had focused on the individual components of quality assurance, such as recruitment, accreditation, and certification, none had examined the relationship between the combined effects of these arrangements as a policy system and the quality of future teachers based on comparable data from many countries.

Method

TEDS-M

The TEDS-M study provided an opportunity to examine the relationship between quality assurance arrangements, such as recruitment, accreditation, and certification, and the quality of future teachers measured by MCK and MPCK based on data collected from a much larger number of countries than the studies by Wang et al. (2003) and Ingersoll et al. (2007).

TEDS-M was sponsored by the IEA and was conducted in 2008. Seventeen countries responded to a general invitation from the IEA for countries to participate: Botswana, Canada, Chile, Chinese Taipei, Georgia, Germany, Malaysia, Norway, Oman, the Philippines, Poland, Russian Federation, Singapore, Spain, Switzerland, Thailand, and the United States. Of these, Canada provided information about policies and context but did not participate in the surveys; Oman provided survey data from future secondary teachers only, Spain from future primary teachers only, Switzerland from German-speaking cantons only, and the United States from public institutions only. Although these countries should not be seen as representative of any wider population of countries, they do cover major regions of the world (e.g., North and South America, Asia, Europe, Africa).

An important challenge for TEDS-M was to ensure that similar types of teacher education programs were being compared across different countries. There was a real possibility that comparisons based on country means on tests of graduate mathematics knowledge, for example, could be misleading because of differences between countries in the levels to which programs prepare graduates to teach. For these reasons, TEDS-M reported separately by program type within countries rather than by country. At the primary level, the program types were lower primary (Grade 4 maximum), primary (Grade 6 maximum), primary/lower secondary (Grade 10 maximum), and mathematics specialists. At the secondary level, the program types were lower secondary (to Grade 10) and lower and upper secondary (to Grade 11 and above).

Sampling Method

Countries participating in IEA studies must meet sample size requirements set by the IEA. To meet the IEA requirements, TEDS-M used a two-stage sampling design within each participating country.[1] In consultation with IEA sampling team members, national research coordinators (NRCs) in each participating country identified all teacher preparation programs, categorizing them by *route* (concurrent, consecutive, apprenticeship) and by *level* (primary, secondary). After some exclusions, such as programs with very small enrollments, the target population in each country was defined as "all (students) in their last year of training enrolled in an institution offering formal opportunities to learn to teach mathematics and explicitly intended to prepare individuals to teach mathematics in any of Grades 1 to 8." Programs preparing future teachers of Grades 1 to 6 are referred to as primary programs; those preparing future teachers of Grades 7 and 8 are referred to as secondary programs. Although all secondary programs sampled prepare future teachers of mathematics at the lower secondary level (Grades 7 and 8), the majority prepare teachers to teach mathematics at higher levels (up to Grade 12) as well.

Institutions were sampled first; minimum sample sizes were set at 50 institutions per country and an effective sample size of 400 future teachers per route and level (where there were fewer than 50 institutions in a country and/or fewer than the required number of future teachers in a route, all were surveyed). Further detail is provided in the TEDS-M technical report (Tatto, 2013). The outcomes achieved by the sampling plan are outlined in Table 1 (sourced from Tatto et al., 2012, Exhibits B4 and B5).

Approximately 22,000 future teachers from 750 programs in about 500 institutions in 16 countries were surveyed and tested for the study. The number of future primary teachers ranged from 86 in Botswana to 2,266 in the Russian Federation, and the number of future secondary teachers ranged from 53 in Botswana to 2,141 in the Russian Federation. Apart from the special case of Singapore, where teacher preparation is concentrated within a single institution (the National Institute of Education [NIE]), the number of participating teacher preparation institutions sampled ranged at the primary level from four in Botswana to 78 in Poland and at the secondary level from three in Botswana to 48 in the Philippines and Russian Federation.

Future primary and secondary teachers completed tests of MCK and MPCK relevant to the level at which they were being prepared to teach. Items spanning four content subdomains (number and operations, algebra and functions, geometry and measurement, and data and chance) were used to assess MCK at both the primary and lower-secondary levels. Items included in the MPCK test were based on a framework that included mathematics curricula knowledge, knowledge of planning for mathematics teaching and learning, and enacting mathematics for teaching and learning (see Tatto, 2013, for details). The tests were administered to future teachers as near as practicable to the end of the final year of their programs.

Striking differences were found among countries in future teachers' knowledge of school mathematics and how to teach it. Mean scores on the MCK test ranged from 345 to 623 (primary) and 354 to 667 (secondary); on the MPCK test, the corresponding range was 345 to 604 (primary) and 394 to 649 (secondary) (Tatto et al., 2012).[2]

Data Collection on Quality Assurance Arrangements

TEDS-M also gathered data at the national level about arrangements for assuring the quality of teacher education programs in participating countries (Ingvarson et al., 2013), which provided a basis for the research presented here. The primary source of data about quality assurance arrangements for each country participating in TEDS-M was the "country report." Responsibility for preparing each country report rested with the official NRC for each country, following guidelines provided by the TEDS-M international team.[3] NRCs were appointed by participating countries and were chosen on the basis of their expert knowledge of their country's teacher education system. In preparing their country reports, NRCs were asked to describe national policies, institutions, and practices for assuring the quality of teachers and teacher education in their country within a common structure, which included the following sections:

Table 1
TEDS-M Sampling Outcomes (Institutions and Future Teachers)

	Primary Sample						Secondary Sample					
	Institutions			Future Teachers			Institutions			Future Teachers		
Country[a]	Eligible Sample[b]	Participated	Response Rate	Eligible Sample[c]	Participated	Response Rate	Eligible Sample	Participated	Response Rate	Eligible Sample	Participated	Response Rate
Botswana	4	4	100%	100	86	86%	3	3	100%	60	53	88%
Chile	36	31	86%	836	657	79%	40	33	83%	977	746	76%
Chinese Taipei	11	11	100%	1,023	923	90%	19	19	100%	375	365	97%
Georgia	9	9	100%	659	506	77%	6	6	100%	116	78	67%
Germany	15	14	93%	1,261	1,032	82%	13	13	100%	952	771	81%
Malaysia	24	23	96%	595	576	97%	7	6	86%	462	389	84%
Norway	16	14	88%	185	159	86%	23	13	57%	242	194	80%
Oman	—	—	—	—	—	—	7	6	86%	288	268	93%
Philippines	41	33	80%	653	592	91%	53	48	91%	800	733	92%
Poland	91	78	86%	2,673	2,112	79%	28	23	82%	355	298	84%
Russian Federation	51	49	96%	2,403	2,266	94%	49	48	98%	2,275	2,141	94%
Singapore	1	1	100%	424	380	90%	1	1	100%	431	393	91%
Spain	50	45	90%	1,259	1,093	87%	—	—	—	—	—	—
Switzerland	14	14	100%	1,230	936	76%	6	6	100%	174	141	81%
Thailand	46	45	98%	666	660	99%	46	45	98%	667	652	98%
United States	60	51	85%	1,807	1,501	83%	56	46	82%	726	607	84%

Note. TEDS-M = Teacher Education and Development Study in Mathematics.
[a]Canada provided information about policies but did not participate in the data collection from institutions and future teachers. Oman provided survey data from future secondary teachers only, Spain from future primary teachers only, Switzerland from German-speaking cantons only, and the United States from public institutions only.
[b]For institutions, the eligible sample is the sample originally nominated, less any that were unable to be included for reasons, such as small enrollments.
[c]For individuals, the eligible sample is all future teachers in the final year of a program.

- The historical context of teacher education and current trends,
- The status of teaching and the relative attractiveness of teaching as a career,
- The context within which teachers carry out their work,
- Recruitment and selection of students entering teacher education programs,
- Assessment and accreditation of teacher education programs, and
- Certification of graduates as ready to enter the teaching profession.

For each section, NRCs were asked to respond to detailed guideline questions. For the section on recruitment and selection of students entering teacher education programs, for example, NRCs were asked to describe who determines the total number of places available for teacher education students and on what basis, what the entry standards are for primary and secondary teaching in terms of prior-level mathematics required and who determines them, how compliance with these standards is assured, how the entry standards compare with those for other university or professional preparation programs, and whether any other external examinations are required at any stage during the program. In the same manner, detailed guideline questions were asked about the accreditation of teacher education programs and entry to the teaching profession (certification).[4]

In preparing the materials for these reports, NRCs met individually with TEDS-M team members on two occasions to discuss matters needing clarification or meriting further elaboration. Contact was also maintained via regular e-mail exchanges. The resulting reports went through several further clarification reviews and iterations between NRCs and TEDS-M team members before finalization and confirmation by NRCs.

Assessing the Strength of Quality Assurance Arrangements

To quantitatively code the strength of quality assurance arrangements, we developed a coding rubric based on the work of Wang et al. (2003), Eurydice (2006), and Ingersoll et al. (2007). For this study, the key components of quality assurance arrangements included policies and practices related to the following:

1. Recruitment and selection of students entering teacher education programs
   a. Strength of control over total number of places available for teacher education students
   b. Attractiveness and status of teaching as a profession and a career
   c. Prerequisites for entry to teacher education programs
   d. The prior academic achievement levels needed to gain entry to the programs
2. Requirements for accreditation of teacher education programs

3. Requirement for certification and full entry to the profession (in addition to graduation from teacher education program)

Each key component was coded using a three-level scoring scheme—"high," "medium," and "low" (or, on occasion, "strong," "moderate," and "weak")—for quality assurance policies and practices. A composite measure, Recruitment and Selection, was constructed by averaging the ratings given to the four elements (a through d) listed above. An overall composite, Quality Assurance Overall Rating, was constructed by averaging the three measures Recruitment and Selection, Accreditation of Programs, and Entry to Profession, giving equal weightings to all three elements.

The overall rating and its three components were correlated with teachers' average knowledge levels upon completion of teacher preparation (Research Question 2) and with national means on international tests of mathematics achievement (Research Question 3). The correlation analyses addressing the second research question were conducted with the quality assurance ratings for each program level: primary ($n = 21$) and secondary ($n = 22$). The unit of analysis in the correlations addressing the third research question was country ($n = 12$ for TIMSS Grade 4, $n = 10$ for TIMSS Grade 8, and $n = 13$ for PISA).

Results

Comparison of Quality Assurance Arrangements in 17 Countries

Countries differed substantially in the strength of the quality assurance arrangements to ensure the quality of the graduates from teacher education programs. Table 2 shows the rubric that was applied to assess the strength of each component along with the list of countries that were coded for each level.

As Section 1, Part A, in Table 2 indicates, some countries rated as strong on control over entry, such as Botswana, Chinese Taipei, Malaysia, Oman, and Singapore, have a national agency that ensures the supply of teachers matches the demand. They limit funding to a specified number of places in each teacher education institution. Countries reporting no legislative mechanisms to control enrollments or the number of providers, such as Chile, Georgia, Norway, Philippines, Spain, Switzerland, and United States, were rated as weak.

Section 1, Part B, in Table 2 indicates that Singapore (Wong et al., 2013) and Chinese Taipei (Hsieh et al., 2013) have specific recruitment policies to ensure that teaching presents an attractive career option in comparison with other professions and, as a consequence, that sufficient numbers of abler students apply for places in initial teacher preparation programs to meet the demand. Teacher salaries in Canada, Chinese Taipei, and Singapore are above average relative to GDP per capita. In Singapore, future teachers are paid a stipend in addition to receiving free teacher education. Teachers in Chinese Taipei also receive benefits, such as education subsidies for their children and a generous pension.

Section 1, Part C1, in Table 2, indicates that the basic requirement for entry to primary teacher education programs in most countries is graduation from secondary school. Most countries (all but Botswana, Norway, Poland, the Russian Federation, and Singapore) have no specific requirement about the level of mathematics achieved in secondary school. However, Chinese Taipei and Germany require evidence of success in university-level mathematics courses before students can gain entry to teacher education courses. To enter programs for future teachers of mathematics at the secondary level, Section 1, Part C2, indicates that graduation from a university with a first degree in mathematics or completion of designated courses at university level is the basic requirement in Canada, Chinese Taipei, Germany, Singapore, and Spain. Other TEDS-M countries require only graduation from secondary school with or without specific mathematics requirements.

Another measure of the strength of recruitment policies in a country is the level of prior academic achievement of entrants to primary teacher education programs. As Section 1, Parts D1 and D2, indicate, most countries classified entrants to teacher education programs as above-average achievers for their age group. Only Singapore reported that most future primary teachers are recruited from the top 20% of the age cohort. Only Singapore, Germany, and Oman reported that future secondary mathematics teachers are recruited from the top 20% of the age cohort.

Requirements for the accreditation of teacher education programs varied greatly across TEDS-M countries. As Section 2 shows, some countries, such as Botswana, Canada, Chinese Taipei, Russian Federation, Thailand, United States, and Singapore, required external evaluation and accreditation of teacher education programs by a government, statutory, or professional agency and with power to disaccredit programs. At the time TEDS-M data were collected, Chile, Georgia, Oman, and the Philippines had unregulated teacher education systems or voluntary accreditation only.

Section 3 shows that requirement for certification and full entry to the profession (in addition to graduation from a teacher education program) also varied significantly among countries in TEDS-M. For most countries (11 out of 17 countries), graduation is seen as a sufficient guarantee that a teacher is competent to practice and leads automatically to official entry to the teaching profession. However, an increasing number of countries are making a distinction between graduation from a teacher education program and gaining a certification to enter the profession, a distinction that is common in most well-established professions. Entry to the profession in Canada, Oman, the Philippines, and most states in the United States depends on meeting performance requirements or passing tests set by external agencies, such as the Ontario College of Teachers in Canada or the California Council on Teacher Credentialing in the United States.

As explained earlier, teacher education graduates in Chinese Taipei must not only pass the Ministry of Education's Teacher Qualification Assessment; they must also undertake further screening and performance assessments when applying for teaching positions at the regional level. In Germany, teacher education is state controlled. Future teachers must pass state examinations at the end of the two phases of teacher education. The first state examination at the end of the first phase of university education (the first phase lasts for 42 months for future primary teachers and 54 months for future secondary teachers) consists of several

Table 2
Quality Assurance Arrangements in Teacher Education in the TEDS-M Countries

Rating	Description	Countries
1. Recruitment and selection for entry to teacher education		
A. Strength of control over total number of places available for teacher education students		
Strong (3)	National agency controls entry numbers	Botswana, Chinese Taipei, Malaysia, Oman, Singapore
Moderate (2)	Universities have some autonomy over enrolments	Canada, Germany, Poland, Russian Federation, Thailand
Weak (1)	No legislative mechanisms to control enrolments or number of providers	Chile, Georgia, Norway, Philippines, Spain, Switzerland, United States
B. Attractiveness and status of teaching as a profession and a career		
High (3)	High demand for teacher education places from abler graduates; salaries above average GDP per capita plus benefits, high status, attractive working conditions	Canada, Chinese Taipei, Singapore
Medium (2)	Salaries near average GDP per capita	Botswana, Germany, Malaysia, Oman, Poland, Russian Federation, Spain, Switzerland, United States (secondary)
Low (1)	Salaries below average GDP per capita; status low	Chile, Georgia, Norway, Philippines, Thailand, United States (primary)
C1. Prerequisites for entry to primary teaching programs		
High (3)	Graduation from secondary school and requirement for tertiary-level studies	Chinese Taipei, Germany
Medium (2)	Graduation from secondary school with specific mathematics requirement	Botswana, Norway, Poland, Russian Federation, Singapore
Low (1)	Graduation from secondary school with no specific mathematics requirement	Canada, Chile, Georgia, Germany, Malaysia, Philippines, Spain, Switzerland, Thailand, United States
C2. Prerequisites for entry to secondary teaching programs		
High (3)	Graduation from a university with a first degree in mathematics or completion of designated courses at university level	Canada, Chinese Taipei, Germany, Singapore, Spain
Medium (2)	Graduation from secondary school with specific mathematics requirement	Botswana, Georgia, Malaysia, Norway, Oman, Poland, Russian Federation, United States
Low (1)	Graduation from secondary school with no specific mathematics requirement	Chile, Philippines, Thailand, Switzerland
D1. Prior academic achievement of entrants to primary teacher education programs		
High (3)	Top 20% of age group	Singapore
Medium (2)	Above-average achievers for age group	Botswana, Canada, Chinese Taipei, Germany, Malaysia, Philippines, Russian Federation, Switzerland, United States
Low (1)	Average achievers for age group	Chile, Georgia, Norway, Poland, Spain
D2. Prior academic achievement of entrants to secondary teacher education programs		
High (3)	Top 20% of age group	Germany, Oman, Singapore
Medium (2)	Above-average achievers for age group	Botswana, Canada, Chinese Taipei, Georgia, Malaysia, Norway (to Year 12), Philippines, Poland (to Year 12), Russian Federation, Switzerland, United States
Low (1)	Average achievers for age group	Chile (to Year 10), Norway (to Year 10), Poland (to Year 10)
2. Accreditation of teacher education programs		
Requirements for accreditation of teacher education programs		

(continued)

Table 2 (continued)

Rating	Description	Countries
High (3)	External evaluation and accreditation of teacher education programs by a government, statutory, or professional agency and with power to disaccredit programs	Botswana, Canada, Chinese Taipei, Russian Federation, Thailand, United States, Singapore
Medium (2)	Agencies responsible for the accreditation of higher education institutions but with limited requirements; no independent, external evaluation	Germany, Spain, Switzerland, Malaysia, Norway, Poland
Low (1)	Unregulated teacher education systems or voluntary accreditation only	Chile, Georgia, Oman, Philippines
3. Entry to the teaching profession		
Requirement for certification and full entry to the profession (in addition to graduation from teacher education program)		
High (3)	Entry to the profession or gaining employment depends on passing further tests of professional knowledge and assessments of performance	Chinese Taipei, Germany
Medium (2)	Entry to the profession depends on passing further tests set by external agencies, e.g., licensure tests of professional knowledge	Canada, Oman, Philippines, United States[a]
Low (1)	Graduation leads automatically to official entry to the teaching profession	Botswana, Chile, Georgia, Malaysia, Norway, Poland, Russian Federation, Singapore, Spain, Switzerland, Thailand

Note. TEDS-M = Teacher Education and Development Study in Mathematics.
[a]For the United States, passing standards for entry to the profession vary considerably across states.

written and oral assessments related to the subjects studied in the first phase as well as a long essay. The second phase normally last for 24 months and is more practical. Future teachers must work part-time at schools and attend courses in general pedagogy and subject-related pedagogy. The second state examination has several components, which include school staff, teacher educators, and state officials observing and assessing candidates as they teach lessons in classrooms. One or more oral examinations can also be included, and an essay on a practical issue is also required before future teachers gain certification.

Table 3 summarizes the findings from Table 2 about quality assurance arrangements in the 17 countries that participated in TEDS-M along the three major components: (a) recruitment and selection for entry to teacher education, (b) accreditation of teacher education programs, and (c) entry to the teaching profession. The 17 countries are listed in the order of the highest overall rating to the lowest overall rating. The composite measure Recruitment and Selection is the mean of the ratings given to the four elements listed in Table 3. An overall measure, Quality Assurance Overall Rating, is the mean of three measures Recruitment and Selection, Accreditation of Programs, and Entry to Profession, giving an equal weight to all three elements.

The variation in every aspect of quality assurance arrangements is substantial. All measures are constructed to have a minimum of 1 (lowest rating on all aspects examined) and a maximum of 3 (highest possible rating on all aspects). On the aggregate quality assurance rating, scores ranged from 1.08 (Chile) to 2.92 (Chinese Taipei). On each of the three components that contributed to that overall mean (Recruitment and Selection, Accreditation of Programs, and Entry to the Profession), scores covered the full range, from the minimum possible (1.00) to the maximum possible (3.00). It is clear that substantial differences in levels of quality assurance arrangements exist among these countries and that the rating system used in this study is capable of identifying and describing these differences.

Quality Assurance Systems and the Knowledge of Future Teachers

As a measure of the knowledge possessed by future teachers of mathematics, this study used data from the TEDS-M study on the MCK and MPCK of students in their final year of preparation for teaching. Summary knowledge data from the TEDS-M study, along with summary quality assurance data from this study, are displayed in Tables 4 and 5. As well as the quality assurance data described above, the tables include the mean scores on the tests of MCK and MPCK for each of 43 program groupings (21 primary and 22 secondary), as reported by Tatto et al. (2012, pp. 139, 143, 147, 150).

The associations between the mean knowledge levels of future teachers and the strength of quality assurance systems under which these programs operate are presented in the correlation coefficients in Tables 4 and 5. Scores on MCK and MCPK are not comparable for primary and secondary programs because different tests were used, so the correlations are presented separately.

Table 3
Comparison of Quality Assurance Arrangements in 17 Countries

	Recruitment and Selection				Elements of Quality Assurance			
Country	Control Over Total Number of Places Available	Attractiveness and Status of Teaching	Prerequisites for Entry	Prior Academic Achievement of Entrants	1. Recruitment and Selection	2. Accreditation of Programs	3. Entry to Profession	Quality Assurance: Overall Rating
Chinese Taipei	3	3	3	2	2.75	3.00	3.00	2.92
Canada	2	3	3	2	2.50	3.00	2.00	2.50
Germany (primary)[b]	2	2	3	2	2.25	2.00	3.00	2.42
Germany (secondary)[b]	2	2	3	3	2.50	2.00	3.00	2.50
Singapore (primary)[b]	3	3	2	3	2.75	3.00	1.00	2.25
Singapore (secondary)[b]	3	3	3	3	3.00	3.00	1.00	2.33
United States (primary)[b]	1	1	2	2	1.50	3.00	2.00	2.17
United States (secondary)[b]	1	2	2	2	1.75	3.00	2.00	2.25
Botswana	3	2	2	2	2.25	3.00	1.00	2.08
Russian Federation	2	1	2	2	1.75	3.00	1.00	1.92
Oman[a]	3	2	2	3	2.50	1.00	2.00	1.83
Thailand	2	1	1	1	1.25	3.00	1.00	1.75
Malaysia[a]	3	2	1	2	2.00	2.00	1.00	1.67
Spain[a]	1	2	3	2	2.00	2.00	1.00	1.67
Poland	2	1	2	2	1.75	2.00	1.00	1.58
Norway	1	1	2	2	1.50	2.00	1.00	1.50
Philippines	2	1	1	2	1.50	1.00	2.00	1.50
Switzerland	1	2	1	1	1.25	1.00	1.00	1.42
Georgia	1	1	1	2	1.25	1.00	1.00	1.08
Chile	1	1	1	2	1.25	1.00	1.00	1.08

[a]Oman did not participate in the Teacher Education and Development Study in Mathematics (TEDS-M) at the primary level; Spain did not participate at the secondary level. No generalist primary mathematics teachers from Malaysia participated in TEDS-M.
[b]Different levels of control between primary and secondary programs were reported by Germany (prior academic achievement of entrants), Singapore (prerequisites for entry) and the United States (attractiveness and status of teaching).

As might be expected, future teachers in secondary programs that make them eligible to teach across the full range of grades in secondary school (e.g., from Grade 7 through Grades 11 and upward) generally scored higher on both the MCK and the MPCK tests than future teachers in programs that made them eligible to teach up to Grade 10 only. Similarly, where countries (Germany, Norway, Poland, Switzerland, Singapore, and the United States) offered two programs for primary teachers, the higher mean knowledge scores were invariably obtained by future teachers being prepared to teach at the higher levels.

It is apparent from Tables 4 and 5 that the mean test scores obtained are highest in countries such as Chinese Taipei and Singapore (where the strength of the quality assurance systems are relatively high compared with the other TEDS-M countries). This is true whether the programs are at primary or secondary level and whether the tests assess MCK or MPCK.

For the overall rating of quality assurance, all four correlations are positive and statistically significant ($p < .01$), and they range from range from 0.55 to 0.60. They differ little whether the knowledge test assesses MCK or MPCK. It is evident that TEDS-M countries with stronger quality assurance arrangements are more likely to be producing future teachers with a sound knowledge of the mathematics they will be expected to teach and the pedagogy they might use.

Which components of quality assurance arrangements seem to be most important? The correlations reported in Tables 4 and 5 suggest that two components, Recruitment and Selection and Accreditation of Programs, might be key factors, as they have the strongest relationship with the two knowledge measures. For primary teacher programs, the relationships are strongest for strength of accreditation systems, whereas for secondary teacher programs, the relationships with knowledge levels differ little between two elements of quality control. The lack of statistically significant relationships in three of the four correlations between MCK/MPCK and Entry to Profession may be explained by the fact that the future teachers have not yet experienced the entry regulations when they participated in the MCK and MPCK assessments at the end of their university program, even though they can anticipate the requirements.

Quality Assurance Arrangements and National Achievement in Mathematics

One of the motivations for TEDS-M was to examine whether the variation in mathematics achievement of students (as

Table 4
Relationships Between Quality Assurance Arrangements and Knowledge of Future Teachers: Primary Programs

Program Group	*n*	Program Outcomes		Quality Assurance Components			Overall Rating of Quality Assurance
		MCK Mean	MPCK Mean	Recruitment and Selection	Accreditation of Programs	Entry to Profession	
Lower primary (Grade 4 maximum)							
Georgia	506	344.7	345.1	1.25	1.00	1.00	1.08
Germany	907	500.7	491.2	2.25	2.00	3.00	2.42
Poland	1,799	456.2	452.0	1.75	2.00	1.00	1.58
Russian Federation	2,260	535.5	511.9	1.75	3.00	1.00	1.92
Switzerland	121	512.2	518.9	1.25	2.00	1.00	1.42
Primary (Grade 6 maximum)							
Chinese Taipei	923	623.2	592.3	2.75	3.00	3.00	2.92
Philippines	592	439.6	457.4	1.50	1.00	2.00	1.50
Singapore	262	586.3	588.3	2.75	3.00	1.00	2.25
Spain	1,093	481.3	492.2	2.00	2.00	1.00	1.67
Switzerland	815	547.9	539.4	1.25	2.00	1.00	1.42
United States	951	517.5	543.6	1.50	3.00	2.00	2.17
Primary/secondary (Grade 10 maximum)							
Botswana	86	441.2	448.2	2.25	3.00	1.00	2.08
Chile	654	413.0	424.8	1.25	1.00	1.00	1.08
Norway (ALU)[a]	392	508.7	539.3	1.50	2.00	1.00	1.50
Norway (ALU+)[a]	159	552.8	564.4	1.50	2.00	1.00	1.50
Primary mathematics specialists							
Germany	97	555.2	552.3	2.25	2.00	3.00	2.42
Malaysia	574	488.4	503.2	2.00	2.00	1.00	1.67
Poland	300	614.2	574.8	1.75	2.00	1.00	1.58
Singapore	117	599.6	603.7	2.75	3.00	1.00	2.25
Thailand	660	528.1	506.4	1.25	3.00	1.00	1.75
United States	132	520.0	544.5	1.50	3.00	2.00	2.17
Correlation with MCK (primary programs only; $n = 21$)				0.49*	0.61**	0.22	0.60**
Correlation with MPCK (primary programs only; $n = 21$)				0.47*	0.61**	0.20	0.58**

Note. MCK = mathematics content knowledge; MPCK = mathematics pedagogy content knowledge.
[a]In Norway, four different types of programs are offered. ALU (allmennlærer-utdanning) programs are general teacher education programs that prepare teachers to teach in both primary and lower-secondary schools. We have used ALU+ to identify ALU students who have opted to take optional extra studies in mathematics. To prepare for teaching senior secondary classes, a 5-year (concurrent) master's program is available. Alternatively, students who have completed a degree in mathematics may undertake a final year (consecutive) program in pedagogy, subject matter didactics, and teaching practice (called the PPU).
*$p < .05$. **$p < .01$.

indicated by the TIMSS and PISA international surveys studies) was related to variation in the nature of their teacher education systems. Is student performance on TIMSS and PISA higher in countries with strong quality assurance arrangements? The first available student assessment data following TEDS-M were TIMSS 2011 and PISA 2012.

Although it is not possible to establish causal relationships, it was possible to examine whether the TEDS-M findings support such a relationship. As shown in Table 6, of the 17 countries, 12 countries participated in TIMSS 2011 at the Grade 4 level, 10 countries participated in TIMSS 2011 at the Grade 8 level, and 13 countries participated in PISA 2012 for 15-year-olds enrolled in schools.

Table 6 reports mean scores on TIMSS 2011 (Grades 4 and 8) and PISA 2012, along with the aggregate quality assurance arrangements at the national level. For Germany, Singapore, and the United States, there were small differences in quality assurance arrangements between primary and secondary programs (see Table 3). The quality assurance ratings for primary programs were used in the computation of TIMSS Grade 4 correlations; for TIMSS Grade 8 and PISA correlations, the quality assurance ratings for secondary programs were used. The data in Table 6 suggest that there is a statistically significant relationship between the overall strength of quality assurance arrangements and student achievement at the national level, with correlations of 0.69 ($p < .01$), 0.76 ($p < .01$), and 0.59 ($p < .05$) with TIMSS 2011

Table 5
Relationships Between Quality Assurance Arrangements and Knowledge of Future Teachers: Secondary Programs

		Program Outcomes		Quality Assurance Components			
Program Group	*n*	MCK Mean	MPCK Mean	Recruitment and Selection	Accreditation of Programs	Entry to Profession	Overall Rating of Quality Assurance
Lower secondary (Grade 10 maximum)							
Botswana	34	435.6	435.5	2.25	3.00	1.00	2.08
Chile	741	354.2	393.6	1.25	1.00	1.00	1.08
Chinese Taipei	365	667.3	649.0	2.75	3.00	3.00	2.92
Germany	406	483.4	515.5	2.50	2.00	3.00	2.50
Philippines	733	441.5	450.4	1.25	1.00	2.00	1.42
Poland	158	528.8	519.7	1.50	2.00	1.00	1.50
Singapore	142	544.4	539.0	3.00	3.00	1.00	2.33
Switzerland	141	531.1	548.6	1.25	2.00	1.00	1.42
Norway (ALU+)[a]	148	461.2	480.0	1.50	2.00	1.00	1.50
Norway (ALU)[a]	344	435.3	455.1	1.50	2.00	1.00	1.50
United States	121	467.7	470.7	1.75	3.00	2.00	2.25
Lower and upper secondary (to Grade 11 and above)							
Botswana	19	448.6	409.1	2.25	3.00	1.00	2.08
Georgia	78	424.5	443.3	1.25	1.00	1.00	1.08
Germany	362	584.6	585.7	2.50	2.00	3.00	2.50
Malaysia	388	493.4	472.0	2.00	2.00	1.00	1.67
Oman	268	472.0	474.3	2.50	1.00	2.00	1.83
Poland	139	548.8	527.7	1.75	2.00	1.00	1.58
Russian Federation	2,139	593.5	566.0	1.75	3.00	1.00	1.92
Singapore	251	586.9	561.8	3.00	3.00	1.00	2.33
Thailand	652	479.0	476.1	1.25	3.00	1.00	1.75
Norway (PPU/master's)[a]	65	502.8	494.5	1.50	2.00	1.00	1.50
United States	354	552.9	542.3	1.75	3.00	2.00	2. 25
Correlation with MCK (secondary programs only; $n = 22$)				0.51*	0.51**	0.35	0.57**
Correlation with MPCK (secondary programs only; $n = 22$)				0.46*	0.40*	0.45*	0.55**

Note. MCK = mathematics content knowledge; MPCK = mathematics pedagogy content knowledge.
[a]In Norway, four different types of programs are offered. ALU (allmennlærer-utdanning) programs are general teacher education programs that prepare teachers to teach in both primary and lower-secondary schools. We have used ALU+ to identify ALU students who have opted to take optional extra studies in mathematics. To prepare for teaching senior secondary classes, a 5-year (concurrent) master's program is available. Alternatively, students who have completed a degree in mathematics may undertake a final year (consecutive) program in pedagogy, subject matter didactics, and teaching practice (called the PPU). Because the master's and PPU programs are similar and the numbers undertaking them are relatively small, they have been combined for reporting purposes in this study.
*$p < .05$. **$p < .01$.

(Grades 4 and 8) and PISA 2012, respectively. Of the components of quality assurance, the Recruitment and Selection aggregate correlated significantly with TIMSS 2011 (Grade 8) and PISA 2012. Accreditation requirements correlated positively with the two TIMSS national means (0.76 and 0.75, both at $p <$ .01 level). For entry to the teaching profession, the correlations were weaker, and only the correlation with the PISA means was statistically significant (0.52 at $p < .05$ level).

Of the components of quality assurance arrangements, the association with TIMSS scores is strongest with accreditation requirements (0.76 and 0.75 for the TIMSS fourth- and eighth-grade tests, respectively; both $p < .01$). The association with PISA is strongest for Recruitment and Selection (0.54, $p < .01$) and entry to the teaching profession (0.52, $p < .05$). As many (e.g., Schmidt, 2014) have noted, the achievements measured by TIMSS and PISA are not the same. Following extensive empirical investigations, Wu (2010) concluded that "a country with a high score in PISA shows that the students are good at 'everyday mathematics,' while a high score in TIMSS shows that the students are good at 'school mathematics'" (p. 96).

Perhaps not surprisingly, it appears that strong accreditation requirements, which may ensure that courses deliver school-appropriate content knowledge, are most strongly associated with TIMSS performance. Entry to the teaching profession, on the

Table 6
Relationships Between Quality Assurance Arrangements and National Mathematics Achievement

Country[a]	Recruitment and Selection	Accreditation of Programs	Entry to Teaching Profession	Overall Rating of Quality Assurance	TIMSS 2011 Grade 4	TIMSS 2011 Grade 8	PISA 2012 15-Year-Olds
Chinese Taipei	2.75	3.00	3.00	2.92	591	609	560
Canada	2.50	3.00	2.00	2.50			518
Chile	1.25	1.00	1.00	1.08	462	416	423
Germany (primary)[b]	2.25	2.00	3.00	2.50	528		
Germany (secondary)[b]	2.50	2.00	3.00	2.42			514
Singapore (primary)[b]	2.75	3.00	1.00	2.25	606		
Singapore (secondary)[b]	3.00	3.00	1.00	2.33		611	513
United States (primary)[b]	1.50	3.00	2.00	2.17	541		
United States (secondary)[b]	1.75	3.00	2.00	2.25		509	481
Russian Federation	1.75	3.00	1.00	1.92	542	539	482
Oman	2.50	1.00	2.00	1.83	385	366	
Thailand	1.25	3.00	1.00	1.75	458	427	427
Malaysia	2.00	2.00	1.00	1.67		440	421
Spain	2.00	2.00	1.00	1.67	482		484
Poland	1.75	2.00	1.00	1.58	481		518
Norway	1.50	2.00	1.00	1.50	495	475	489
Switzerland	1.00	2.00	1.00	1.42			531
Georgia	1.25	2.00	1.00	1.08	450	431	
Correlation with TIMSS, Grade 4 ($n = 12$)	0.48	0.76**	0.28	0.69**			
Correlation with TIMSS, Grade 8 ($n = 10$)	0.57*	0.75**	0.31	0.76**			
Correlation with PISA ($n = 13$)	0.54*	0.33	0.52*	0.59*			

Note. TIMSS = Trends in International Mathematics and Science Study; PISA = Programme for International Student Assessment.
[a]The Philippines did not participate in TIMSS or PISA assessments, and only Year 6 students were tested in Botswana. Therefore, these countries are excluded from the table.
[b]Quality assurance ratings for Germany, Singapore, and United States differed slightly between primary and secondary programs. Primary ratings were used in the computation of TIMSS Grade 4 correlations; secondary ratings were used in the computation of TIMSS Grade 8 and PISA correlations.
*$p < .05$. **$p < .01$.

other hand, reflects strong selection policies to identify the most capable applicants for teaching courses and is more strongly associated with PISA performance ($r = .52$, $p < .05$) than with TIMSS performance (correlations of 0.28 and 0.31, both $p > .05$).

There is, of course, no direct link between the students to whom the TIMSS and PISA tests were administered in 2011 and the future teachers who participated in TEDS-M in 2008. At the time that TIMSS 2011 and PISA 2012 tests were administered, only a small percentage of teachers in any country could have been participants in the TEDS-M project. The relationship between the mathematics knowledge of graduating teachers and the relative achievement of the specific students they teach in subsequent years would appear to be worth investigating in subsequent studies.

Discussion and Conclusions

Policies and practices related to quality assurance in teacher education varied considerably across the 17 TEDS-M countries, specifically, those related to ensuring the quality of entrants to teacher education programs, the quality of teacher education programs, and the quality of graduates who gain full entry to the teaching profession. We found statistically significant associations between the overall strength of these quality assurance arrangements and the quality of graduates, as measured by the tests of MCK and MCPK used in TEDS-M. Countries with strong quality assurance arrangements, such as Chinese Taipei and Singapore, scored highest, whereas countries with weaker arrangements, such as Georgia and Chile, tended to score lower on these measures. We also found a statistically significant relationship between quality assurance arrangements and the mathematics achievement of students (as measured by the TIMSS and PISA international assessments).

These findings have important implications for policymakers concerned with promoting teacher quality through investing in teacher education. Quality assurance system through policies and practices in teacher education does matter, and we found no country reaching the highest achievement levels both in future teachers' knowledge of the content and teaching and student learning without a strong quality assurance system. This study points to the importance of ensuring that policies designed to promote teacher quality at each stage are coordinated and mutually supportive. They need to cover the full spectrum—from policies designed to make teaching an attractive career to abler

students to policies for assuring that entrants to the profession have attained high standards of performance. Each of the components of quality assurance has statistically significant association with at least some of the desired outcomes in this study (MCK, MPCK, TIMSS, and PISA). For Recruitment and Selection, the correlations are consistent and moderately high, ranging from 0.46 to 0.57. For Accreditation of Programs, the correlations with TIMSS, MCK, and MPCK (range 0.40 to 0.76) are consistently higher than with PISA (0.33). As noted above, entry to the profession correlates most strongly with PISA scores.

In summary, Recruitment and Selection is consistently associated with all of the desirable outcomes, Accreditation of Programs most strongly with school content–related content measures, and Entry to the Profession with an outcome focused less directly on school content and more on the ability to use mathematics in the outside world. All three components of quality control appear to matter, but not in the same way.

We have noted previously that requirements for entry to the profession may not impact future teachers until after they have completed their teacher preparation courses, which is where they learn their mathematics content. This may explain its weaker association with the content-related measures MCK, MPCK, and TIMSS. Of the school achievement measures in this study, entry to the profession was significantly associated only with PISA, which measures the extent to which school students are able to go beyond the mathematics content that they learn in the classroom. Perhaps supervised experience and strong mentoring early in their careers enable teachers to develop their capacity to teach these skills to an extent that typical teacher preparation programs do not.

Do the countries rated strong in one component of quality assurance arrangements also excel in the other components? Interestingly, the correlations among the three components are low (range 0.05 to 0.39) and statistically nonsignificant. This indicates that each country has the scope to identify and strengthen some aspects of quality assurance, and it is plausible, but not guaranteed, that such change would lead to improved outcomes.

Our analysis of TEDS-M data also builds on and extends earlier research on teacher quality by Wang et al. (2003) and Ingersoll et al. (2007). Some other studies, such as the McKinsey study (Barber & Mourshed, 2007), focused only on the influence of stringent recruitment and selection policies in a small number of countries that included Singapore and Finland. For example, this study shows that countries, such as Chinese Taipei and Singapore, that do well on international tests of student achievement, such as TIMSS and PISA, not only ensure that teaching can compete successfully with other professions for high-quality entrants to teacher education; they also have strong systems for reviewing, assessing, and accrediting teacher education providers. Chinese Taipei has strong mechanisms for ensuring that graduates meet high standards of performance before gaining certification and full entry to the profession. In Singapore, the single provider of teachers, the NIE, is governed by a council chaired by the permanent secretary of the Ministry of Education (the major employer of teachers in Singapore), ensuring that NIE is highly accountable for the quality of its graduates.

Although each is important, this study, and others reviewed here, suggests that both recruitment and accreditation (which have the highest positive associations with all of the desired outcomes in this study) should be important considerations for policymakers. As the effects of attracting sufficient teachers of high academic ability in the first place flow through to affect the quality of teacher education programs and the quality of graduates and new teachers, effective recruitment is a necessary, though not sufficient, condition in assuring the quality of future teachers. No matter how strong accreditation and certification policies might be, they are unlikely to compensate in situations where governments do not ensure that teaching has high status and that it provides career pathways comparable in salary to other professions that attract and recruit the ablest graduates.

However, although many recent policy reports increasingly point to the importance of teacher quality (e.g., OECD, 2011, 2014), most TEDS-M countries reported that teaching was in fact losing its ability to attract academically able students. Due to budget restraints, policymakers may set aside one of the main factors affecting the quality of applicants for teacher education places and focus instead, for example, on holding teacher educators more accountable or on tougher selection tests or performance assessments for licensing purposes. Whether these are wiser investments in the long run remains to be seen. But the evidence indicates that relative salaries matter in terms of student achievement (Akiba et al., 2012; Carnoy et al., 2009; Dolton & Marcenaro-Gutierrez, 2011). Detailed cost-benefit studies might potentially shed light on whether, in the long term, making salaries and conditions more attractive to the ablest graduates might be a more effective investment if it leads to higher retention rates, lower performance management costs, more effective professional learning, and ultimately, greater quality and equity in student learning outcomes.

Similarly, policies to assure the quality of entrants to teacher education may focus on recruitment or on selection. More rigorous selection policies alone may achieve little without ensuring that sufficient quality applicants apply in the first place. A recent report on teacher education commissioned by the Australian government, for example, called for more rigorous selection into teacher education but failed to acknowledge that recruitment was the main problem, not selection; few entrants to many teacher education programs were recruited from the top 25% of high school graduates (Ingvarson, 2016; Teacher Education Ministerial Advisory Group, 2014). Australia has a recruitment problem more than a selection problem, but it costs less to develop and administer selection tests than to build more attractive salary structures.

Future research in this area would benefit from more discriminating measures of quality assurance policies at the accreditation and certification stages. Although two countries may both have national accreditation bodies, the nature and rigor of the assessment procedures involved may be very different. A clear trend in countries like Australia, the United Kingdom, and the United States is from evidence based on program "inputs" to program "outcome" measures (e.g., Council for the Accreditation of Educator Preparation, 2013). Researchers are clarifying the characteristics of effective teacher education programs (e.g., Darling-Hammond & Bransford, 2005), but more research is needed on how best practice can be made common practice in teacher education. Data collected as part of TEDS-M provided some countries with the opportunity to conduct within-country

studies analyzing program characteristics explaining the variation in outcome measures of MCK and MPCK (e.g., Blömeke, Kaiser, & Lehmann, 2010).

A wide variation in the strength of quality assurance system across countries is to be found at the initial certification stage. This is a critical transition period. There is increasing recognition that the first few years after graduation need to be seen as a period of professional preparation in its own right, with its own distinct learning objectives under supervised practice, as is the case in other professions, such as medicine. The transition from graduation to certification then becomes a staged process of further standards-guided professional learning around aspects of teaching that can be developed effectively only when new teachers begin to work in schools (American Federation of Teachers, 2012; Thorpe, 2014). High-achieving countries require and support a period of mentored induction followed by rigorous assessments of readiness for full entry to the profession. Although Singapore does not have strong measures in place at the commencement of employment, the close relationship between the major employer (Singapore government) and the sole provider (NIE) and the rigor of its program review process ensures that program graduates can perform at the level expected by their likely employer (Wong et al., 2013). Graduate teachers in Chinese Taipei must also pass the Ministry of Education's Teacher Qualification Assessment before gaining a teaching credential, and if they apply for a teaching position, they must participate in additional onsite screening and selection processes (Hsieh et al., 2013).

A limitation of this study is that our quality assurance categories and measures were broadly defined. Recruitment policies, for example, can be quite different in different countries. Policy initiatives in the United States related to recruitment have more commonly focused on providing "alternative" routes into teaching than on making teaching a more attractive career option to the ablest graduates, relative to other career options (National Academy of Education, 2009). In contrast, recruitment policy in Singapore and Chinese Taipei focuses on making salaries and working conditions for teachers very attractive and linking supply of new teachers closely to demand (Wong et al., 2013). The Ministry of Education in Singapore controls the number of places for teacher education. The Chinese Taipei government limits funding to a specified number of places in each teacher education institution. The number of institutions has been reduced and is now concentrated in high-status universities.

Another limitation of this study is that the correlations presented here do not establish causal relationships and do not indicate that changing these policies in one or more countries will lead directly to improvements in achievement levels in those countries. The countries participating in TEDS-M varied greatly in many ways, culturally and developmentally. It may be that the consistent high performance of countries such as Chinese Taipei and Singapore can be attributed to aspects of their culture—in particular, to the high value placed on learning and striving for achievement in those countries. We should hardly be surprised, however, to find that these countries also take steps to ensure that teachers are thoroughly prepared to deliver the outcomes they seek. The limited evidence that we have suggests that in these systems, high levels of achievement can be obtained.

Who is responsible for quality assurance? As mentioned, a characteristic of high-achieving countries in this study is that quality assurance policies and practices are strong at all three stages—but especially at the stages of recruitment and selection and accreditation of teacher education programs. They seem to regard quality assurance arrangements as a shared responsibility between governments, teacher education providers, and the profession. They do not regard quality assurance as simply a matter of holding providers more accountable, for example, through more outcome-based accreditation arrangements. Nor do they focus on higher entry standards and tougher selection methods without first ensuring that a sufficient proportion of academically successful students apply for teacher education in the first place. An integrated approach to ensuring the quality of future teachers with shared responsibilities for recruitment and selection, accreditation of programs, and entry to profession would likely lead to a system that supports high-quality instruction and student learning.

NOTES

[1]Full details of the sampling design are provided in Tatto (2013, chap. 6).

[2]Following the approach of the Trends in International Mathematics and Science Study (Mullis, Martin, Foy, & Arora, 2012) and the Programme for International Student Assessment (Organisation for Economic Co-operation and Development, 2014) the mathematics content knowledge and mathematics pedagogy content knowledge scores were standardized to have international means of 500 and standard deviations of 100.

[3]Details of these procedures and condensed versions of these reports can be found in Schwille, Ingvarson, and Holdgreve-Resendez (2013).

[4]These can be found in Ingvarson et al. (2013). Abridged versions of all country reports can be found in Schwille et al. (2013).

REFERENCES

Akiba, M., Chiu, Y., Shimizu, K., & Liang, G. (2012). Teacher salary and student achievement: A cross-national analysis of 30 countries. *International Journal of Educational Research*, *53*, 171–181.

Akiba, M., LeTendre, G., & Scribner, J. (2007). Teacher quality, opportunity gap, and National achievement in 46 countries. *Educational Researcher*, *36*(7), 369–387.

American Federation of Teachers. (2012). *Raising the bar: Aligning and elevating teacher preparation and the teaching profession*. Washington, DC: Author. Retrieved from http://www.aft.org/pdfs/highered/raisingthebar2012.pdf

Barber, M., & Mourshed, M. (2007). *How the best performing school systems come out on top*. London, UK: McKinsey & Co.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., & Yi-Miau, T. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal*, *47*(1), 133–180.

Beauchamp, G., Clarke, L., Hulme, M., & Murray, J. (2013). *Research and teacher education: The BERA-RSA inquiry. Policy and practice within the United Kingdom*. Project report. London, UK: British Educational Research Association.

Blömeke, S., Kaiser, G., & Lehmann, R. (Eds.). (2010). *TEDS-M 2008: Professional competence and learning opportunities for beginning primary teachers in international comparison*. Munster, Germany: Waxman.

Carnoy, M., Beteille, T., Brodziak, I., Loyalka, P., & Luschei, T. (2009). *Teacher education and development study in mathematics (TEDS-M): Do countries paying teachers higher relative salaries have higher student mathematics achievement?* Amsterdam, Netherlands: International Association for the Evaluation of Student Achievement.

Chevalier, A., Dolton, P., & McIntosh, S. (2007). Recruiting and retaining teachers in the UK: An analysis of graduate occupational choice from the 1960s to the 1990s. *Economica*, *74*(293), 69–96.

Council for the Accreditation of Educator Preparation. (2013). *CAEP accreditation standards; as approved by the CAEP Board of Directors*. Washington, DC: Author.

Darling-Hammond, L., & Bransford, J. (Eds.). (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco, CA: Jossey-Bass.

Department of Education, Science and Training. (2006). *Attitudes to teaching as a career: A synthesis of attitudinal research*. Canberra, Australia: Commonwealth of Australia.

Dolton, P., & Marcenaro-Gutierrez, D. (2011). If you pay peanuts you get monkeys? A cross-country analysis of teacher pay and pupil performance. *Economic Policy*, *26*(65), 5–55.

European Association for Quality Assurance in Higher Education. (2009). *Standards and guidelines for quality assurance in the European higher education area*. Helsinki, Finland: Author. Retrieved from http://www.enqa.eu/wp-content/uploads/2013/06/ESG_3edition-2.pdf

European Commission. (2013). *EU performance and first inferences regarding education and training policies in Europe*. Brussels, Belgium: Author. Retrieved from http://ec.europa.eu/dgs/education_culture/repository/education/policy/strategic-framework/doc/pisa2012_en.pdf

European Commission/EACEA/Eurydice. (2015). *The teaching profession in Europe: Practices, perceptions, and policies*. Eurydice report. Luxembourg: Publications Office of the European Union.

Eurydice. (2006). *Quality assurance in teacher education in Europe*. Brussels, Belgium: European Commission.

Feuer, M. J., Floden, R. E., Chudowsky, N., & Ahn, J. (2013). *Evaluation of teacher preparation programs: Purposes, methods, and policy options*. Washington, DC: National Academy of Education.

Furlong, J. (2013). *Inspecting initial teacher education in England: The work of Ofsted*. Paper commissioned for the National Academy of Education project on Evaluation of Teacher Education Programs: Toward a Framework for Innovation. Washington, DC: National Academy of Education.

Goulding, M., Rowland, T., & Barber, P. (2002). Does it matter? Primary teacher trainees' subject knowledge in mathematics. *British Educational Research Journal*, *28*, 689–704.

Hill, H.C., Rowan, B., & Ball, D. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, *42*, 371–406.

Hsieh, F-J., Ling, P-J., Chao, G., & Wang, T-Y. (2013). Preparing teachers of mathematics in Chinese Taipei. In J. Schwille, L. Ingvarson, & R. Holdgreve-Resendez (Eds.), *TEDS-M encyclopaedia: A guide to teacher education context, structure, and quality assurance in 17 countries* (pp. 71–85). Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

Ingersoll, R., Boonyananta, S., Fujita, H., Gang, D., Kim, E. G., Lai, K. C., & Wong, A. F. L. (2007). *A comparative study of teacher preparation and qualifications in six nations*. Philadelphia, PA: Consortium for Policy Research in Education.

Ingvarson, L. (2016). Attracting the best and brightest. *Journal of Professional Learning*, Semester 2, 1–5. Retrieved from http://cpl.asn.au/journal/semester-2-2016/attracting-the-best-and-brightest

Ingvarson, L., Elliott, A., Kleinhenz, E., & McKenzie, P. (2006). *Teacher education accreditation: A review of national and international trends and practices*. Canberra, Australia: Teaching Australia, the Australian Institute for Teaching and School Leadership.

Ingvarson, L., Schwille, J., Tatto, M., Rowley, G., Peck, R., & Senk, S. (2013). *An analysis of teacher education context, structure, and quality-assurance arrangements in TEDS-M countries: Findings from the IEA teacher education and development study in mathematics*. Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

Kang, M., & Hong, M. (2008). Achieving excellence in teacher workforce and equity in learning opportunities in South Korea. *Educational Researcher*, *37*(4), 200–207.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, NJ: Lawrence Erlbaum.

Mourshed, M., Chijioke, C., & Barber, M. (2010). *How the world's most improved school systems come out on top*. London, UK: McKinsey & Co.

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. Chestnut Hill, MA: Boston College. Retrieved from http://timssandpirls.bc.edu/timss2011/downloads/T11_IR_Mathematics_FullBook.pdf

National Academy of Education. (2009). *Education policy white paper on time for learning* (B. Rowan, Ed.). Washington, DC: Author.

Organisation for Economic Co-operation and Development. (2005). *Teachers matter: Attracting, developing and retaining effective teachers*. Paris, France: Author.

Organisation for Economic Co-operation and Development. (2011). *Strong performers and successful reformers: Lessons from PISA for the United States*. Paris, France: Author.

Organisation for Economic Co-operation and Development. (2013). *Lessons from PISA 2012 for the United States: Strong performers and successful reformers in education*. Paris, France: Author. http://dx.doi.org/10.1787/9789264207585-en

Organisation for Economic Co-operation and Development. (2014). *PISA 2012 results: What students know and can do. Student performance in mathematics, reading and science* (Vol. 1, rev. ed.). Paris, France: Author. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-volume-i.htm

Sahlberg, P. (2011). Developing effective teachers and school leaders: The case of Finland. In L. Darling-Hammond & R. Rothman (Eds.), *Teacher and leader effectiveness in high-performing education systems* (pp. 13–22). Washington, DC: Alliance for Excellent Education.

Schleicher, A. (2013). Lessons from PISA outcomes, *OECD Observer*, *297*(Q4).

Schleicher, A. (2012). *Preparing teachers and developing school leaders for the 21st century: Lessons from around the world*. Paris, France: OECD. Retrieved from https://www.oecd.org/site/eduistp2012/49850576.pdf

Schleicher, A. (2014). *Equity, excellence and inclusiveness in education: Policy lessons from around the world*. International Summit on the Teaching Profession. Paris, France: OECD. Retrieved from http://dx.doi.org/10.1787/9789264214033-en

Schmidt, W. (2014). *PISA and TIMSS: A distinction without a difference?* Washington, DC: Albert Shanker Institute. Retrieved from http://www.shankerinstitute.org/print/2688

Schwille, J., Ingvarson, L., & Holdgreve-Resendez, R. (Eds.). (2013). *TEDS-M encyclopaedia: A guide to teacher education context, structure, and quality assurance in 17 countries*. Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

Tatto, M. T. (2013). *The Teacher Education and Development Study in Mathematics (TEDS-M): Policy, practice, and readiness to teach primary and secondary mathematics in 17 countries. Technical*

report. Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

Tatto, M. T., Schwille, J., Senk, S. L., Ingvarson, L., Rowley, G., Peck, R., Bankov, K., Rodriguez, M., & Reckase, M. (2012). *Policy, practice, and readiness to teach primary and secondary mathematics in 17 countries: Findings from the IEA Teacher Education and Development Study in Mathematics (TEDS-M)*. Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

Teacher Education Ministerial Advisory Group. (2014). *Action now: Classroom ready teachers*. Canberra, Australia: Australian government, Department of Education.

Thorpe, R. (2014). Residency: Can it transform teaching the way it did medicine? *Phi Delta Kappan*, *96*(1), 36–40.

Tucker, M. S. (Ed.). (2012). *Surpassing Shanghai*. Cambridge, MA: Harvard Education Press.

Wang, A., Coleman, A., Coley, R., & Phelps, R. (2003). *Preparing teachers around the world*. Princeton, NJ: ETS.

Wilson, S., & Youngs, P. (2005). Research on accountability processes in teacher education. In M. Cochran-Smith & K. Zeichner (Eds.), *Studying teacher education: The report of the AERA Panel on Research and Teacher Education* (pp. 591–644). Washington, DC: American Educational Research Association.

Wong, K. Y., Lim-Teo, S. K., Lee, N. H., Boey, K. L., Koh, C., Dindyl, J., . . . Cheng, L. P. (2013). *Preparing teachers of mathematics in Singapore*. In J. Schwille, L. Ingvarson, & R. Holdgreve-Resendez (Eds.), *TEDS-M encyclopaedia: A guide to teacher education context, structure, and quality assurance in 17 countries* (pp.193–207). Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

Wu, M. (2010). *Comparing the similarities and differences of PISA 2003 and TIMSS* (OECD Education Working Papers, No. 32). Paris, France: OECD Publishing.

Youngs, P., & Grogan, E. (2013). United States of America (USA). In J. Schwille, L. Ingvarson, & R. Holdgreve-Resendez (Eds.), *TEDS-M encyclopaedia: A guide to teacher education context, structure, and quality assurance in 17 countries* (pp. 255–272). Amsterdam, Netherlands: International Association for the Evaluation of Educational Achievement.

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