Not So Elementary

Primary School Teacher Quality in Top-Performing Systems

Teacher Quality Systems in Top-Performing Countries

LEARNING FIRST

CENTER ON INTERNATIONAL EDUCATION BENCHMARKING
LEARNING FROM THE WORLD'S HIGH PERFORMING EDUCATION SYSTEMS

This report is one of a series of reports on teacher quality systems in top-performing countries commissioned by the Center on International Education Benchmarking (CIEB) of the National Center on Education and the Economy (NCEE). In addition to these reports, researchers have collected authentic tools used by the systems highlighted to assist policymakers and practitioners interested in adapting lessons learned for their own context and culture. Funding for this report came from the National Center on Education and the Economy. Marc Tucker, NCEE's President and Betsy Brown Ruzzi, Director of CIEB provided guidance and direction to the research and policy analysis.

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Ben Jensen, Katie Roberts-Hull, Jacqueline Magee and Leah Ginnivan

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Table of Contents

Figures

Boxes

Executive Summary

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Concerns about inadequate development of subject expertise for American elementary school teachers have been well documented.[1] Issues have been identified at every step along the teacher development pathway:

- Teacher education programs are relatively unselective, meaning that the preexisting math, science, and literacy expertise of entrants is generally not strong.[2]
- Teacher education programs then spend minimal time developing teacher subject expertise and have course assessments that do not require deep knowledge or skill.[3]
- Once they have graduated from teacher education, prospective teachers may have to take some exams, but these are minimally challenging.[4]
- When applying for jobs, adequate subject expertise is often not an important factor in the hiring process.[5]
- When in the classroom, American teachers are often without the required support, meaningful subject-specific professional learning, and high-quality instructional materials, all of which aid subject expertise development in high-performing countries.[6]

There are many exceptions to this narrative, and there are many exemplary U.S. teacher preparation programs. However, it is clear that, overall, the preparation of elementary teachers in the United States in key subject areas has been inadequate.[7]

Given the importance of quality teaching to student learning, it is not hard to draw a line between these issues and poor performance in student outcomes. So what are systems that have high-performing learning outcomes in key subjects doing to ensure quality teaching in math, science and literacy?

This report analyses whether and how high-performing systems have supported the subject expertise of their elementary school teachers.

The findings highlight how different parts of these systems constantly reinforce the development of deep subject expertise in their elementary teachers. For example, these systems have:

1. Teachers selected for the specific knowledge and skills that make an effective elementary teacher.
2. Initial teacher education that is focused on how to teach the elementary school curriculum.
3. Instructional supports which develop deep subject expertise in teachers.
4. Professional development and mentoring from teacher subject experts who have been promoted to these positions because of both their subject expertise and ability to help other teachers.
5. Recognition and promotion for all teachers based on teacher subject expertise, encompassing school-based research and their ability to develop other subject teachers.

Methods

It is well-established that teacher quality is one of the most important determinants of student learning and that teacher subject expertise is a key component of teaching quality. But less is known about how to improve teacher quality and subject expertise for elementary teachers.

The high-performing[8] jurisdictions of Japan, Finland, Hong Kong, and Shanghai provide useful details on which policies help ensure elementary teacher subject expertise. These four systems are among the highest performing on the 2012 PISA and each has students who are many months, if not years, ahead of U.S. students in reading, math and science. (See Figure 2) Each of these systems has a considerable focus on developing subject expertise of elementary teachers. But to understand how this occurs requires deeper analysis than, for example, simply looking at whether they have specialist teachers in their elementary schools (i.e., teachers who only teach 1-2 subjects). In fact, while Shanghai and Hong Kong have specialist elementary school teachers, Finland and Japan have generalist elementary teachers like most of the United States, which suggests that there are approaches to building subject expertise other than requiring subject specialist teachers. Looking at both specialist and non-specialist systems provides lessons that can be applied regardless of context.

Findings

These systems utilize four main policies that span teachers' careers to increase elementary teacher subject expertise. Many of these policies address the exact same problems that bedevil the United States in elementary education. They include:

a) **Selection of candidates with strong subject expertise.** This can happen at various stages along the teacher development pathway from entry into initial teacher education to hiring and promotion decisions. All four high-performing systems have strong assessments of teacher subject expertise.

b) **Specialization.** Each of the four high-performing systems requires elementary teachers to develop specialized subject expertise in one or a few subjects. In Hong Kong and Shanghai, elementary school teachers teach fewer subjects so they have time to develop deeper knowledge in those subjects. Even the generalist systems of Japan and Finland still require teachers to study one or two subjects in-depth during initial teacher education. Often, these teachers will become a teacher leader in their specialist subject area, which helps schools ensure that each department is led by a subject expert who can share knowledge.

c) **Foundational content preparation in initial teacher education.** Initial teacher education is structured to emphasize deep subject expertise in foundational concepts. Courses focus on developing a deep understanding of the subjects taught in elementary school rather than a shallow understanding of advanced content. For example, an elementary math program requires a deep understanding of arithmetic – the mathematical concepts and proofs it embodies – and how to teach it rather than only college-level math (e.g., calculus), which is useful but not as important for teaching in elementary school. Understanding these trade-offs is crucial in any reform debate.

Figure 1 How Many Months Behind? Differences in PISA Performances, 2012

	U.S. Reading	U.S. Math	U.S. Science
Shanghai	22	39	26
Hong Kong	14	23	18
Japan	12	16	16
Finland	8	11	15

< 1 year behind
1 to 2 years behind
> 2 years behind

Source: OECD, 2014
Note: Figures represent the difference in performance (expressed in the number of months of school education) between students in the U.S. and four high-performing systems.

d) **Subject-specific support in schools.** New teachers continue developing their subject expertise during induction periods, with subject mentors, quality textbooks and teaching materials, and access to subject experts in the school. Professional learning is strongly oriented to the development of pedagogical content knowledge that is, by definition, subject specific. As teachers advance their subject expertise, they become professional learning leaders in their specialty subjects and work to improve other teachers' subject expertise across the school, region, and system as a whole.

These four policies interact with each other and with other aspects of K-12 education (e.g., the curriculum). These interactions signify systems that continually develop and reinforce the importance of subject expertise in elementary school teaching.

When education leaders continually emphasize the importance of subject expertise, it sends unambiguous messages to all parts of the education system. Teacher assessments of subject expertise signal its importance to effective teaching. School curriculum that requires students to develop a deep understanding of subject expertise sends a message about the teachers required to deliver the curriculum. And when system leaders deliver instructional materials that support instruction involving deep pedagogical content knowledge, it sends a clear signal to the profession and those who train and develop teachers.

Over time, these messages, if delivered consistently, have an impact. They change the expectations of what is required to become an effective elementary teacher. Districts and regions offer more support to develop elementary teacher subject expertise, professional development providers change their focus to gain market share, and universities follow suit, especially when they are included in reforms to develop subject expertise across the system.

Introduction

Despite years of policy interventions, there has been little improvement in key areas of student achievement in the last decade, and U.S. students are still behind many other advanced nations.[9] While evidence is conclusive that improving teaching is the biggest in-school lever available, few policy reforms in the United States have resulted in significant improvements to teaching and learning.

This report focuses on how to improve teaching in elementary school math, science and literacy. The evidence on teaching and learning in these areas is examined alongside policy reforms in the development of elementary teacher expertise in these subjects in the top-performing systems around the world.

There is strong evidence that teacher subject expertise has a significant impact on student outcomes.[10] The most effective teachers have a strong knowledge of not just the subject itself (content knowledge) but also how to teach the subject (pedagogical content knowledge).

It seems obvious that teachers should know the subjects they are teaching, but mastery of the knowledge for teaching goes further than having the general knowledge that most adults have. Teachers need to be able to "unpack" knowledge to show the steps for learning. They need to understand how to best represent the subject to students and anticipate student thinking.[11] Teachers need to know at which age students can conceptualize different ideas and how new lessons will interact with prior knowledge.

Strong subject expertise is required for effective teaching at all levels of education. This is well-understood for teachers in the upper years of secondary education but is too regularly absent from debate on improving elementary school teaching, even in key subject areas. This is the case despite the fact that subject expertise for elementary school teaching is highly specialized and requires strong initial training and ongoing continuous development.[12]

Subject expertise definitions

The term **subject expertise** is used to refer to any subject-specific knowledge that teachers need. This includes:

> **Content knowledge:** what teachers need to know about the subject.
>
> For example, a teacher knows that words have different origins, such as Greek or Latin, and that word roots have meaning (e.g., *mal* is a common Latin root that means "bad.")
>
> **Pedagogical content knowledge:** What teachers need to know about *how to teach* the subject.
>
> For example, a teacher knows that students from Spanish-speaking backgrounds will already know words with Latin roots and makes a plan to help students identify and make connections between English and Spanish words that have the same roots (e.g., the Spanish word *mal* and the English word *malicious)*.

In the United States, there are concerns about problems with elementary teacher subject expertise and with the development opportunities teachers receive. For example, in 2008, Newton found that only 15 percent of teachers in preservice education were able to accurately describe a conceptually appropriate procedure for solving the problem 2/4 - 3/6. This means that 85 percent of preservice teachers were unable to demonstrate conceptual flexibility and mastery in addition of fractions, a vital concept throughout elementary and secondary education.[13] After completion of initial teacher education, expertise is still lacking. A 2014 report revealed that almost two-thirds of teachers think their teacher preparation programs left them unprepared for the realities of the classroom.[14]

Issues with teacher subject expertise do not end with preservice teachers. A 2014 study used OECD data to compare the numeracy and literacy skills of teachers in 23 countries. Compared to their peers in Finland and Japan and other English-speaking countries, teachers in the United States have lower skills than all of these countries in math and the second lowest in literacy (see Figure 2).[15]

Among all teachers, elementary school teachers may have a particular need for improved subject expertise

Too many people assume that it is not too difficult to possess the necessary subject expertise to teach elementary school students – that any college graduate would be able to teach any of the content that nine-year-olds learn at elementary school.

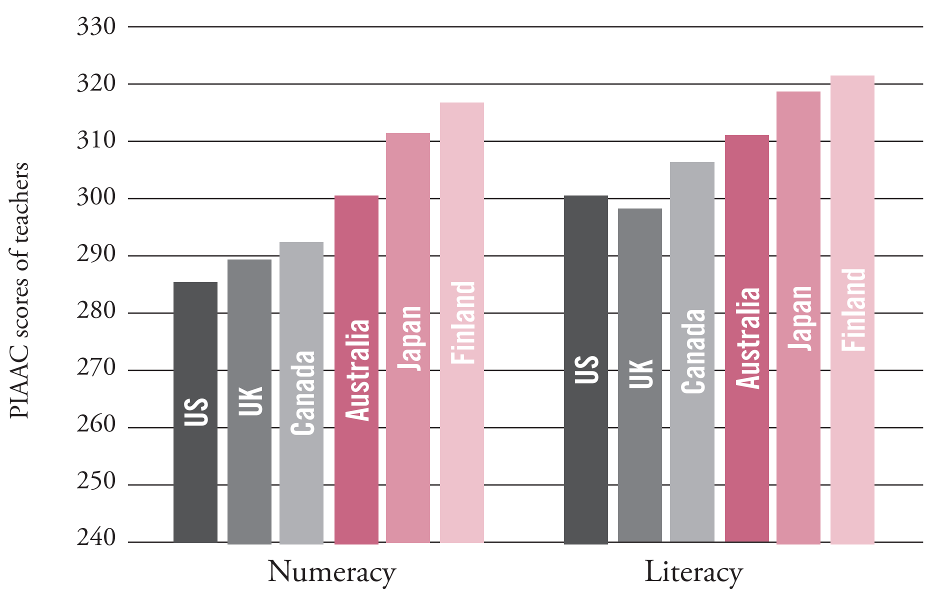
However, the subject expertise required for teaching is specialized – and significantly different than what one would learn in general secondary and tertiary education. Elementary school teachers need a strong foundational understanding of the content taught in elementary school, and many college graduates do not have deep expertise at this level. This is why just getting "smarter" candidates to go into teaching will not be enough to significantly improve instruction, especially for elementary school students. Teachers need not only deep understanding of the foundational content taught in elementary schools, but also knowledge of how to help students learn this content. This subject expertise is a strong determinant of teacher effectiveness and student learning, a logical finding that has been supported by many studies across a range of subject areas.[16]

Getting this right matters. The quality of teaching and learning in elementary school affects later academic and life outcomes. For example, whole-number knowledge in first grade is a strong predictor of students' understanding of fractions in seventh and eighth grade.[17] Early reading skills are critical to future achievement, but learning to read is one of the most challenging proficiencies to acquire.[18] The imperative to focus efforts on supporting student learning during the elementary years of schooling is clear.

This report looks at systems around the world that have succeeded in producing high student outcomes in science, math and literacy. Finland, Hong Kong, Japan and Shanghai top the international league tables on student outcomes in these areas.[19] They also have well-developed but different policies specifically aimed at increasing elementary teacher subject expertise that shed light on potential reform in the United States and other countries.

The report begins with summaries of the key features of how Finland, Hong Kong, Japan and

Figure 2 Teacher Literacy and Numeracy Skills by Country (2012 PIAAC Survey)



Source: Hanushek, Piopiunik, & Wiederhold, 2014

Shanghai each develop elementary teacher subject expertise. Chapters 3 and 4 present the evidence on teacher subject expertise and how it impacts the quality of teaching and learning in math, science and literacy. It is important to note that this research is predominantly Western research, with much of it originating in the United States. It sets the scene for how this research has driven many of the policies in Finland, Hong Kong, Japan and Shanghai.

The first of the key policy areas – teacher selection – is discussed in Chapter 5. While much policy debate concentrates on selectivity early in teachers' careers (e.g., at entry into initial teacher education as is done in Finland), the chapter also highlights the type of selection policies Japan uses later in teacher development (using a rigorous employment exam) which also help ensure only teachers with expertise are teaching children.

Chapter 6 looks at specialization in the development and work of elementary school teachers. Importantly, this report focuses on two countries that have specialized elementary school teacher roles (i.e., teachers in Hong Kong and Shanghai who teach only 1-2 subjects) and two countries with generalist teacher roles (Finland and Japan) that more closely resemble the situation in the United States but still manage to ensure high levels of subject expertise.

Chapters 7 and 8 focus on how subject expertise is developed through education and training of elementary teachers. Chapter 7 focuses on initial teacher education and warns against simplistic calls for all teachers to have master's degrees or to take courses in math and science faculties. Instead, the focus should be on developing the subject expertise required to effectively teach elementary school curriculum. In-service teacher professional development is the focus of Chapter 8 which highlights how subject-specific professional learning can build teacher subject expertise across teachers' careers.

A summary of the main policy implications for the United States from all of these policy areas is then presented in Chapter 9.

Box 1 An Example of How Subject Expertise Improves Teaching

Two elementary school teachers, Ms. Keating and Ms. Smith, are planning a lesson on two-digit subtraction with regrouping. Ms. Keating's math subject expertise is relatively underdeveloped: while she completed math courses during her recent undergraduate program, they were mostly focused on advanced math topics (e.g., pre-calculus) and not elementary school content. She's received some general classroom management advice from more experienced teachers at her school but hasn't had much conversation about the best way to teach subtraction.

Ms. Smith, on the other hand, has strong subject expertise. In her initial teacher education program, she completed a minor in elementary school math where she took courses aimed specifically at foundational math content knowledge and pedagogical content knowledge. She has also had five years of experience teaching in a school with a strong culture of subject-specific professional learning. She participates in a teacher research group where she collaborates with others to analyze student learning in math, and she has a mentor teacher with math expertise.

Both teachers begin the lesson with the example 62–37.

Ms. Keating shows the steps to the regrouping procedure by explaining that "you can't take a bigger number (7) away from a smaller number (2), so you need to borrow from 2's next-door neighbor (6) to complete the equation." Ms. Keating knows that manipulatives are important, so she asks students to explore this new learning by completing an activity using marbles. She has the students start with 62 marbles and take 37 away, to see how many are left. Unfortunately, this use of manipulatives does not actually show the process of regrouping.

Ms. Smith takes a different approach. Using the same example, 62–37, Ms. Smith has students attempt the problem based on their previous experience with simpler subtraction. When they realize they can't subtract 7 from 2, she asks students whether it is possible to subtract a number in the 30s from a number in the 60s. Students agree that it is possible. Then, Ms. Smith makes a connection for students that for this problem, there aren't enough ones, but for other problems, there are too many ones. The students remember doing addition with carrying, and Ms. Smith explains that just as they have previously learned to compose ones into tens, for this problem they will learn to decompose tens into ones.

Ms. Smith also uses manipulatives but chooses bundled popsicle sticks to explain how 10 is 1 ten or 10 ones. She shows how 5 tens and 12 ones is the same as 6 tens and 2 ones, even though nothing has been added or subtracted yet. She has the students use the sticks to try to solve the problem of 62–37 and then leads the class through a discussion of each student approach, scaffolding the class to select the strategies they believe are the most appropriate to help solve the problem.

The different approaches to teaching this topic leave students with different levels of understanding. Some students in Ms. Keating's class are confused by the term *borrowing*: they have learned that when you borrow something, you need to return it later, and they wonder when this happens in subtraction. Others have an incomplete understanding: they think you can arbitrarily change the value of a number when you need to, or that the two digits that make up a two-digit number are "neighbors" – and not actually part of the same number. In subsequent classes, they try to apply the regrouping procedure to more advanced problems (e.g., larger numbers) and struggle. They are also confused when later learning about negative numbers because they believed larger numbers could not be subtracted from smaller numbers (since this was part of Ms. Keating's explanation for the regrouping procedure).

Conversely, students in Ms. Smith's class have a more appropriate conceptual understanding of decomposing units of higher value (e.g., 1 ten into 10 ones), and they are able to apply this to larger numbers in subsequent lessons (e.g., 1 hundred into 10 tens). They understand how this concept relates to previous topics they have encountered, including addition. Ms. Smith's students are also able to generate other ways to regroup than the standard procedure – e.g., subtracting 30 from 62 (instead of 37) to get 32, and then adding back 7. This helps them learn to solve problems in multiple ways and become more fluent in subtraction.

Example adapted from Ma, 1999

1 System Summaries

Teachers gain subject expertise not just through one experience but in different phases across a teacher development pathway. Policy interventions can target different points along this pathway, from selection into a teacher education program to the first years of teaching in a school.[20] Between each development phase are opportunities for policymakers to create filters or gateways to assess teachers entering the profession.[21]

Finland, Shanghai, Hong Kong, and Japan use different policies to improve teacher subject expertise, but they have many similarities. A short summary of each system's policies along the teacher development pathway is below.

1.1 Finland

Finland demonstrates high levels of both achievement and equity in education.[22] Finland is known for having highly educated teachers trained in selective initial teacher education programs.[23] In fact, Finnish teachers have some of the highest cognitive skills in both literacy and numeracy in the world.[24] In Finland, elementary school teachers tend to teach all (or most) subjects but may study one or two subjects more deeply as minors during initial teacher education.

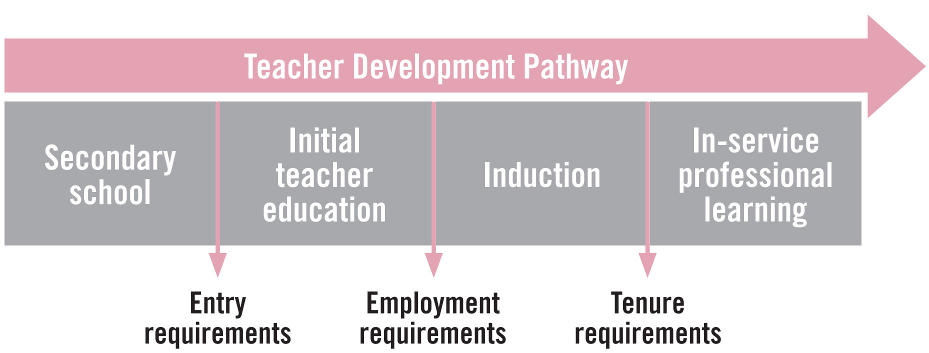
Finland is a small education system with about the same student population of an average state in the United States. There are over 900,000 students in total – more than half of whom are in basic education.[25] Basic education comprises nine years and is for children 7-16 years old. Students then go to upper secondary education for the next three years. There are around 60,000 teachers.[26]

In Finland, the Ministry of Education and Culture is responsible for education. The Finnish National Board of Education works with the Ministry to develop educational goals and develops and approves the national guidelines for curriculum design. Local municipalities are responsible for providing education and individual schools have autonomy in designing curricula based on national guidelines.[27]

1.1.1 Entrance to initial teacher education

Each initial teacher education provider in Finland rigorously tests its applicants. This testing process generally involves two phases. The first phase involves the examination of candidates' matriculation results. Initial teacher education providers have the autonomy to determine the weight placed on different elements of matriculation. For example, some institutions may choose to take candidates' senior math scores into account, while others will focus primarily on candidates' literacy.[28]

Figure 3 The Teacher Development Pathway



In the second phase of testing, candidates take the VAKAVA examination.[29] All initial teacher education providers in Finland can utilize this examination, which includes a series of multiple-choice questions, based on academic material published approximately six weeks before the exam. As part of the examination, applicants nominate (i.e., list a desire to attend) a maximum of six education degree programs across the country. The second phase of testing often involves interviews and sample lessons.[30]

The list of academic sources and the examination questions from the 2015 VAKAVA examination are included in the Appendix.

1.1.2 Initial teacher education programs

There are eleven teacher training programs, all housed within eight of Finland's universities.[31] These 11 programs have been part of the universities since 1974.[32] Prior to this, there had been a number of satellite campuses that contained the teacher training schools. A government policy incentivized universities to absorb these training schools in an attempt to increase the size and rigour of teacher training institutions.[33]

Universities typically offer both undergraduate and post-graduate teacher education programs with varying specializations. It takes around five years for prospective teachers to complete their training and become a qualified teacher.[34]

1.1.3 Initial teacher education curriculum

Although there is no common curriculum for initial teacher education programs in Finland, all teaching qualifications share the same organizing structure and are underpinned by similar principles.[35] As part of the Bologna process, Finnish universities responsible for teacher education collaborated to develop 'a common structure of teacher education' and 'the core contents of the curriculum'.[36] There are still differences between the curricula of different universities, however, reflecting the autonomy of the institutions. All prospective Finnish teachers are introduced to the Finnish national school curriculum and expected to know it well by the time they enter schools to teach, as adherence to a national curriculum is considered a key driver of equity in Finland.[37]

All elementary (known as 'class') teachers in Finland must receive a Master of Education Degree of 120 credits in order to certify as a teacher.[38] The Master's program typically focuses on pedagogical studies and research with scope for students to undertake a minor in one or two particular subjects. This is demonstrated in the structure of the University of Jyväskylä class teacher Master's program, which dictates 80 credits of "education studies" (comprising pedagogy and research-focused units), 35 credits of elective studies and 5 credits of language and communication studies. One credit is equivalent to about 27 hours of study.[39]

Practicums, called "teaching practice," are embedded into initial teacher education at all Finnish institutions. The practicum is considered an important part of teacher education in Finland, as it gives candidates the opportunity to trial and refine their theoretical understanding of classroom practice through practical experience.[40]

Practicums in Finland take place in teacher training schools, which are connected to universities, and in separate "field schools."[41] University teacher training schools are staffed by expert teachers, some with specialist training in particular subject areas. Teacher training schools are also thoroughly vetted to ensure their staff are competent to work with student teachers.[42]

Prospective teachers in Finland also complete a major thesis during their Master's program. The University of Helsinki teaches qualitative and quantitative research methodology to support students' rigorous engagement with their chosen body of literature. Depending on the scope of the thesis, the Master's degree can take up to six years to complete. Some of the articles produced by teacher candidates on the basis of their thesis research are published in prestigious international journals, reflecting their high quality.[43]

1.1.4 In-service professional learning

The Finnish National Board of Education places a strong emphasis on the importance of continuing professional development for teachers. In 2015, the Finnish National Board of Education targeted funding available to support programs of professional development. Institutions were able to bid for this additional funding, and many universities were successful in obtaining these funds to develop new programs.

Three days of professional development per year are mandated in Finnish schools, plus three hours per week for common preparation time in schools. This time is typically used for staff development and study of the curriculum. It is specifically not to be used for lesson or unit planning.

1.2 Shanghai

Shanghai has undergone substantial education reform over the last 30 years. It became one of the first cities in China to achieve universal elementary and junior secondary education[44] and now ranks number one in reading, mathematics and science on the PISA assessments.[45] Elementary teachers in Shanghai are specialists and teach just one or two subjects. Elementary school teachers are known for having strong subject expertise, particularly in mathematics.[46]

Shanghai has approximately 1.4 million students in elementary and secondary education with about 100,000 teachers.[47] Students attend elementary (primary) school for six years from ages 7 to 13 and then secondary school for 4-5 years.[48]

The national Ministry of Education designs school curriculum and funds initial teacher education. The Shanghai Municipal Education Commission develops provincial-specific curriculum based on central guidelines, provides school district funding, and sets the standards for teacher training and employment. Curriculum implementation and school funding is coordinated at the district level.[49]

1.2.1 Initial teacher education programs

Historically, three types of institutions have offered initial teacher education in China. These include

- secondary schools that prepare students to be pre-school and elementary teachers and issue a high school diploma,
- normal colleges that prepare students to be junior-secondary teachers and issue a sub-degree, and
- normal universities that issue bachelor's degrees and prepare students to teach in senior-secondary schools.[50]

Initial teacher education in Shanghai is distinct from the rest of China in that all prospective teachers are trained within tertiary institutions.[51] During the 1990s, the Shanghai Municipal Government required candidates undertaking initial teacher education in secondary schools and normal colleges to have their qualifications upgraded to normal university qualifications. Now, all new teachers for all grade levels have university-level qualifications. As a result, more than 60 percent of elementary school teachers in Shanghai held a Bachelor's degree or higher in 2012.[52]

Normal universities also coordinate the selection of initial teacher education candidates in Shanghai.[53] There are two normal universities with teacher training schools in Shanghai – Shanghai Normal University and East China Normal University.

1.2.2 Initial teacher education curriculum

While many elements of the teacher development pathway are centralized in China or controlled by the municipalities, universities in Shanghai have relative autonomy over their teacher education curricula.[54] The initial teacher education curricula for teachers at Shanghai Normal University and East China Normal University involves general pedagogy and subject-specific training in the education and relevant discipline faculties, with elementary school teachers typically taking their courses in the education faculty.

At Shanghai Normal University, prospective elementary school teachers can choose to take their pedagogical studies in one of three specific discipline strands: language-social sciences, math-natural sciences, and performance or fine arts and crafts.[55] Because elementary teachers are specialists, there is more space in the initial teacher education curriculum to go deeper into content knowledge. Therefore, prospective elementary school teachers are not only prepared with foundational content at the elementary school level, but are also exposed to high-level content knowledge through their pedagogical studies. For example, elementary mathematics candidates will learn to teach relatively advanced mathematical concepts including calculus and linear algebra.[56] All students are also expected to complete a thesis as part of their studies.

Prospective elementary school teachers at Shanghai Normal and East China Universities must also undertake a practicum as part of their qualification. Students undertake an 8-week practicum placement either at schools around Shanghai (Shanghai Normal University)[57] or schools in other parts of East China (East China Normal University) Initial teacher education candidates at Shanghai Normal University also have the opportunity to complete an internship as part of their 4-year Bachelor of Education, which involves a 2-week practicum block at the beginning of each term from their third year of study in addition to the 8-week practicum.[58]

1.2.3 In-service professional learning

Shanghai has a significant focus on subject-specific professional learning embedded in teachers' everyday practice. Every teacher must participate in regular teacher research groups, lesson groups, lesson observation, mentoring and demonstration classes.[59]

While the Shanghai Municipal Education Commission sets high-level professional learning policies and guidelines, district academies are the key delivery body for professional learning. They oversee, design and deliver professional learning for schools.

The Shanghai Municipal Education Commission sets hourly requirements for professional learning. Beginning teachers undertake more than 300 hours in their first 3-5 years,[60] and more experienced teachers applying for a promotion must undertake more than 500 hours of professional learning over five years.[61] The expectation is that every in-service teacher undertakes 10-20 percent city-level courses, 30-40 percent district-level courses and 50 percent school-level training.[62]

Districts decide what professional learning curriculum teachers undertake, tailored to each subject. Universities offer in-service teacher development as do city and district education colleges.

1.3 Hong Kong

Hong Kong has implemented major reforms over the last 15 years to improve learning and teaching. The level of Hong Kong students' reading competency has steadily increased since 2003 and in 2012 Hong Kong ranked 2nd in PISA.[63] It is also ranked 3rd in mathematics and 2nd in science.[64]

Hong Kong has about 700,000 students in total – about 300,000 elementary (primary) students and 400,000 secondary students. There are about 50,000 teachers for these students.[65]

There are three types of schools in Hong Kong: government schools (funded and operated by the government), aided schools (funded by the government but independently operated), and private schools. Most schools fall into the first two categories and are government funded.[66] The Hong Kong Education Bureau funds these schools and outlines policies they follow around curriculum and school administration.

1.3.1 Initial teacher education programs

Initial teacher education in Hong Kong is situated within five higher education institutions that tend to be differentiated by the level they prepare candidates to teach. Most elementary school teachers receive their initial teacher education training at the Hong Kong Institute of Education, the main initial teacher education provider for both early childhood and elementary school teachers.[67]

The institute has ambitions to offer more secondary teacher programs from 2015-16 onwards, and the Hong Kong government has recently announced that the institute will become a university and be re-named The Education University of Hong Kong.[68]

A tertiary qualification is required to become a teacher in Hong Kong and there are five available training pathways, four of which are pre-service routes and one of which is an in-service route.[69] The four pre-service routes are:

1. Bachelor of Education: 5 years in duration, mainly taken by elementary teachers.
2. Double degrees: 5 years in duration, a combination of Bachelor's in a specific subject area and Bachelor's in education taken concurrently. Mainly taken by secondary school teachers.
3. Diploma in Education: 5 years in duration, taken concurrently with a subject-specific degree, leading to a Bachelor's degree with a teaching qualification.
4. Full-time post-graduate degree in education: 1 year in duration.[70]

The in-service degree is a part-time post-graduate qualification taken over two years. It is called "in-service" because it is an apprenticeship-style pathway where candidates study for their qualification part-time while working as a teacher in a school.[71] The number of places in each pathway is set by government quota.[72]

1.3.2 Initial teacher education curriculum

Tertiary institutions in Hong Kong are largely autonomous when it comes to setting their curricula.[73] While there are no mandated standards to guide the length or content of initial teacher education courses in Hong Kong, all programs include 'pedagogical, subject and professional discipline knowledge and skills and placement experience'.[74] The practical experience during the Hong Kong Institute of Education undergraduate program includes preparatory theoretical training in the first two years of the program and a seven-week practicum block in each of the final two years of the program.[75] Students must receive positive feedback on their teaching from their placement school in order to pass the field experience unit of their program.[76]

There is also a clear focus on specialization at the elementary level in Hong Kong. Prospective elementary school teachers studying for an undergraduate program can choose to specialize in a particular subject, such as mathematics. For example, HKIEd offers a Bachelor of Education (Honours) (Primary) in Mathematics.[77] There is less specialization for elementary teachers studying science, because science is part of a curriculum topic called 'general studies', which also includes 'personal, social, and humanities education' (similar to social studies) and technology education.

It is recommended that elementary teacher candidates studying in a post-graduate stream 'should have completed a degree with substantial coverage of their chosen subject specialization'.[78]

1.3.3 Induction

The Hong Kong Education Bureau offers a centralized, 3-day induction program for all new teachers, which is co-organized with the Hong Kong Teachers Centre, a professional development body.

The induction program includes sessions on curriculum run by government experts in each subject, and other general sessions by non-profits on such topics as diversity in schools.

The most recent induction in August 2015 involved around 400 new teachers who were about to start in the classroom.[79]

1.3.4 In-service professional learning

There is a strong focus on continuing professional development in Hong Kong. The Committee on Professional Development of Teachers and Principals (formerly The Hong Kong Advisory Committee on teacher education and Qualifications) recommends an approach to in-school professional development that 'recognizes and facilitates teachers' efforts to continuously refresh and upgrade themselves, as in done in most major professions'.[80]

The teacher competencies are underpinned by six core values (belief that all students can learn, love and care for students, respect for diversity, commitment and dedication to the profession, collaboration, sharing and team spirit, passion for continuous learning and excellence) and one basic premise: the personal growth and development of teachers. Teachers can be evaluated as "threshold," "competent" or "accomplished" against the competency descriptors for each of the domains.[81]

1.4 Japan

Japan is a high-performing education system that has improved significantly from 2009 to 2012. Among OECD countries, Japan is now ranked second in mathematics performance and first in both reading and science performance on PISA.[82]

Japan is a large education system with more than 13 million students, including more than 6 million in elementary school. Japan has about 900,000 teachers, including more than 400,000 elementary teachers.[83] Elementary school goes from grades 1 to 6 (ages 6-12) and secondary school is split between junior high school (3 years) and high school (3 years). Elementary school teachers in Japan are usually generalists, teaching all or most subjects.

Japan's Ministry of Education, Culture, Sports, Science and Technology has overarching responsibility for all levels of education, including teacher education policy. Japan is divided into prefectures and municipalities, each with its own board of education.[84] The prefectural boards are responsible for employment of teachers and funding municipalities. Municipal boards conduct in-service training and oversee daily school operations.[85]

1.4.1 Initial teacher education programs

Initial teacher education programs in Japan are provided by a number of different institutions, including universities, graduate schools and junior colleges, though all courses are provided by a university faculty or an affiliated institution.[86] In total, there are around 1,300 providers of initial teacher education in Japan, all of which are subject to centralized accreditation overseen by the Japanese education ministry.[87]

While each of these institutions has some degree of autonomy over the structure of its program(s), course structure and content must adhere to the general requirements set out by law in the *Act of Teachers' Certificates* and the *Order of Regulations of the Act of Teachers' Certificates*.[88] Individual initial teacher education programs specifically train candidates to teach particular levels: elementary (ages 6 to 12), junior high (ages 12 to 15) or senior high (ages 15 to 18).[89]

1.4.2 Initial teacher education curriculum

The education ministry mandates the number of content and pedagogy credits that initial teacher education candidates are required to accrue as part of their qualification. For example, elementary school teaching Bachelor's degree candidates must take a minimum of 41 pedagogical credits. There are three types of certification available to teachers in Japan – advanced (requiring a Master's degree), type I (requiring a Bachelor's degree) and type II (requiring a Junior College Associate Degree). The great majority of elementary teachers have Bachelor's degrees and only a few have a Master's. Teachers with junior college degrees (Type II certificates) are generally expected to eventually get a Bachelor's degree.[90]

Unlike secondary school teachers, elementary school teachers are required to be able to teach all subjects within the elementary school curriculum.[91] All teachers must take a 'common core' of subjects, including: language, health, humanities, social sciences and sciences, as well as additional courses in their subject matter focus.[92] Secondary teachers, who are required to specialize in a particular subject, need more credits in their chosen subject area than do elementary school teachers.[93]

All teachers are also required to complete a thesis and undertake a practicum, though the practicum block of 2-4 weeks is shorter relative to many other systems.[94] The practicum length is not mandated by the ministry, but the Japan Association of Universities of Education recommends the practicum block go for a minimum of three to four weeks.

1.4.3 Licensing and hiring

After graduation from an accredited teacher training institution in Japan, prospective teachers are granted a license to teach. The license is awarded on the basis of meeting the initial teacher education course requirements, and there are no additional exams that teachers must take. However, being a licensed teacher does not guarantee employment. Each prefecture has a rigorous employment exam which ranks teachers to ensure only the most capable candidates are hired.

Many more teachers are certified each year than will be able to obtain teaching jobs. In 2013, fewer than 1 in 4 licensed teachers were hired as elementary school teachers.[95]

A copy of the Saitama Prefecture employment exam is included in the appendix.

1.4.4 Induction

In-service training to foster both practical leadership qualities and a sense of duty in new teachers is required by law in Japan.[96] The requirement is implemented in different ways by individual prefectures.

In Saitama prefecture, for example, new teachers take part in 300 hours of in-school supervision and advice, in addition to 23 days of external training through the Prefectural Education Centre. The training involves lectures, seminars and practical lessons that cover topics including:[97]

- Foundational principles of education
- Readiness to be a teacher
- Class management
- Subject area leadership
- Morals education
- Foreign language activities
- Cross-curricular learning time
- Special activities
- Student guidance
- Careers counselling
- Administrative workload

Saitama has decided to prioritize science teaching because of a decline in student interest in science, and because most teachers do not have much of a background in science. Two things have been most effective in developing science teacher skills: developing teachers' knowledge of the scientific process and ability to conduct experiments in class, and establishing class teaching flows to have students develop their own thinking. Importance is placed on developing students' ability to use scientific reasoning, rather than just transmission of knowledge.[98]

Demonstration lessons are fairly common in many prefectures. The demonstrating teachers usually have some special skill, or have previously been selected for a special training program. The demonstrating teachers are recommended by each municipality based on classroom observations. The Prefectural Education Board chooses the demonstrator from these candidates.

As part of their science subject development in their induction year, all new teachers observed a 'super-teacher', who had previously been part of a one-year specialist science teacher training program in the area.[99]

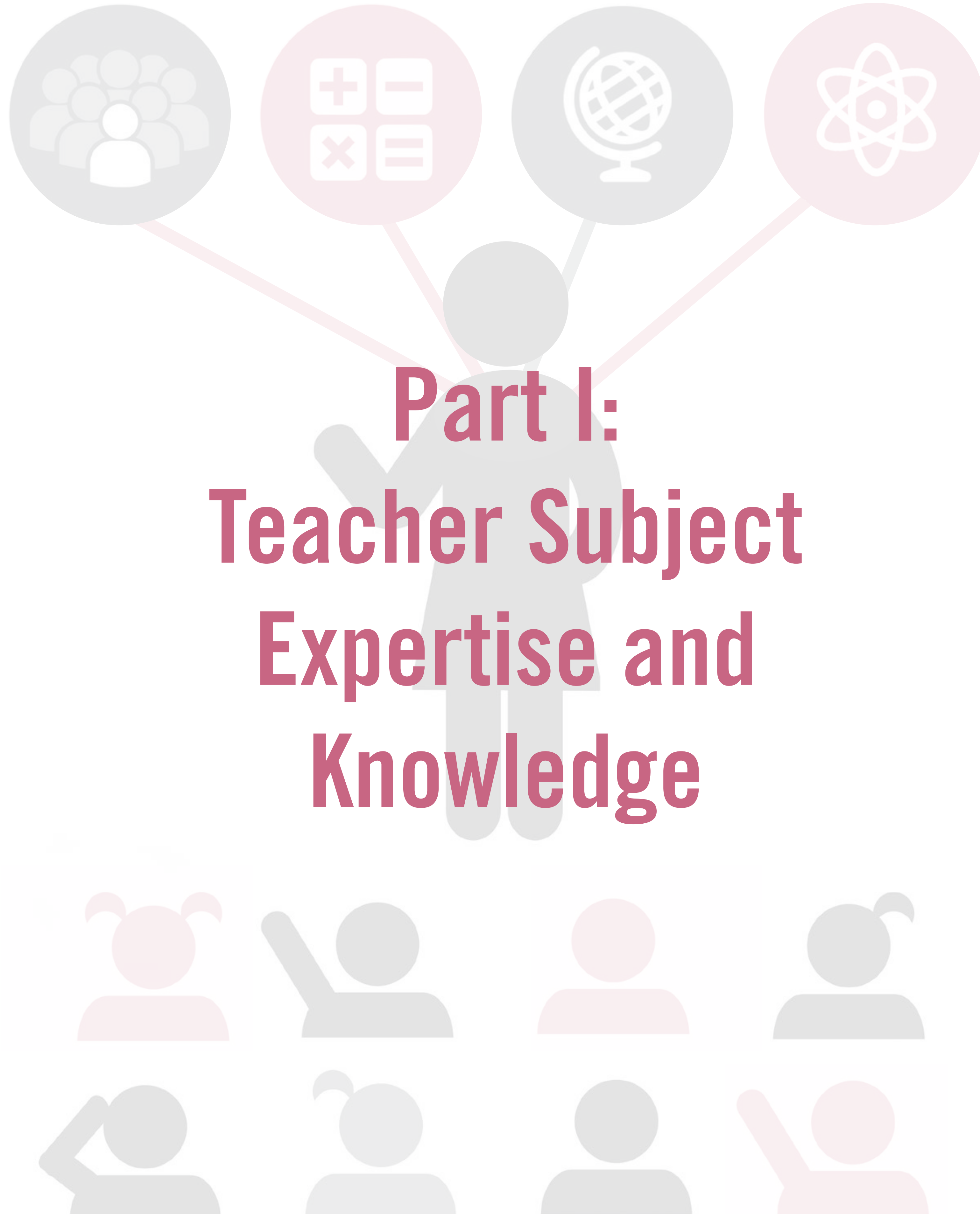
In some prefectures, such as the Tokushima prefecture, in-school practical training is provided by experienced teachers at the same school. These teachers receive an additional sum of about 10,000 yen ($83 USD) over the year for the additional workload, but the prestige of the role is considered to be the true reward.[100]

1.4.5 In-service professional learning

Almost all Japanese elementary teachers engage in an ongoing professional development project – lesson study.[101] Lesson study allows teachers to critically analyze teaching to develop knowledge about what works best to help students learn. The goals of lesson study are broader than just improving one lesson: teachers engage in discussion and lesson observation as part of lesson study to improve their overall subject expertise and particularly pedagogical content knowledge.

Lesson study is a shared process where teachers work collaboratively to develop, teach, analyze, and refine lessons, and has a long history in Japanese schools (over 120 years)[102]. It has an explicit focus on student learning goals and is designed to incrementally build subject expertise across an entire teaching staff.[103] Groups of teachers explicitly set goals for student learning and work towards it through a cycle of research, practice, and reflection.

Part I: Teacher Subject Expertise and Knowledge



2 Teacher Subject Expertise

While the concepts and skills taught in elementary school can appear straightforward, they are not necessarily simple or easy. Elementary school mathematics, for example, requires teachers to not only know strategies to reach correct answers, but also have an understanding of why those strategies work and how students might misunderstand them. Scientific concepts taught to children, such as ideas about life cycles or evolution, are often complex and many adults and children alike only partially understand them (see below sections for further descriptions of the required knowledge in math, science, and literacy teaching).

These are complicated matters, and it shouldn't be assumed that adults have the required knowledge. Rather, there is a specific body of knowledge that teachers need: subject expertise for teaching.

The subject expertise required for teaching is not the same as the knowledge held by the average adult because most adults have procedural knowledge without understanding much about why those procedures work.

For example, most adults know how to read fluently, and this requires adults to not have to think about the sounds and parts of each word as they are reading, so they can think about the meaning of a sentence rather than about individual words. However, teachers need to be able to "unpack" the mechanisms involved in reading and notice and work with phonemes (the building blocks of words). This unpacked knowledge helps teachers understand how to best teach the subject and understand how students learn.[104]

Teachers also need to know how students develop understanding of different subjects, which is not knowledge that adults generally have. For example, science teachers need to know at which age students can conceptualize ideas like outer space, and how new lessons will interact with their prior knowledge about the world to develop connections and meaning.

There is a growing consensus that two types of subject expertise are necessary to teach well:[105]

- **Content knowledge:** a deep foundation of factual knowledge about the subject being taught
- **Pedagogical content knowledge:** understanding of how to best teach the subject

Though content knowledge and pedagogical content knowledge can be measured separately,[106] in practice, of course, they are woven together since pedagogical content knowledge draws on a base of content knowledge, plus an understanding of pedagogy and student learning.

While the importance of subject expertise is well-known, less is known about how it is developed and less still about what policies support the preparation of effective teachers.[107]

Research has been improving, but many studies have used poor indicators to gauge subject expertise and have therefore had trouble making definitive conclusions about how best to improve it. Research cannot yet say exactly how initial teacher education and in-school supports can most effectively develop this knowledge in teachers.

Figure 4 Two Types of Subject Expertise

Content knowledge:

- Knowing facts and concepts in the subject
- Understanding organization and structure of the discipline

Example: Understanding why cross-multiplication works

Pedagogical content knowledge:

- Knowing best ways to represent ideas
- Understanding student preconceptions and partial understandings
- Anticipation of student thinking

Example: Knowing the best two numbers to first demonstrate cross-multiplication to students

Source: Shulman, 1986

Therefore, this report summarizes the small evidence base of required elementary teacher knowledge in three subjects: math, literacy, and science. It also shows four examples of systems (Shanghai, Hong Kong, Japan, and Finland) that are known for having highly knowledgeable teachers and how they have structured systems to prepare teachers with strong subject expertise. The goal is to help policymakers generate ideas for new policies to pilot and evaluate in their own systems.

2.1 Content knowledge

Elementary school teachers should have, at the minimum, a deep, flexible, and accurate knowledge of the content they will be teaching to students. Without strong conceptual understanding of the content, teachers are not well equipped to help students. This general idea has been supported by a range of reports and studies since the 1980s.[108] It may seem obvious, but research shows that effective teachers generally know more about the subjects they are teaching.[109]

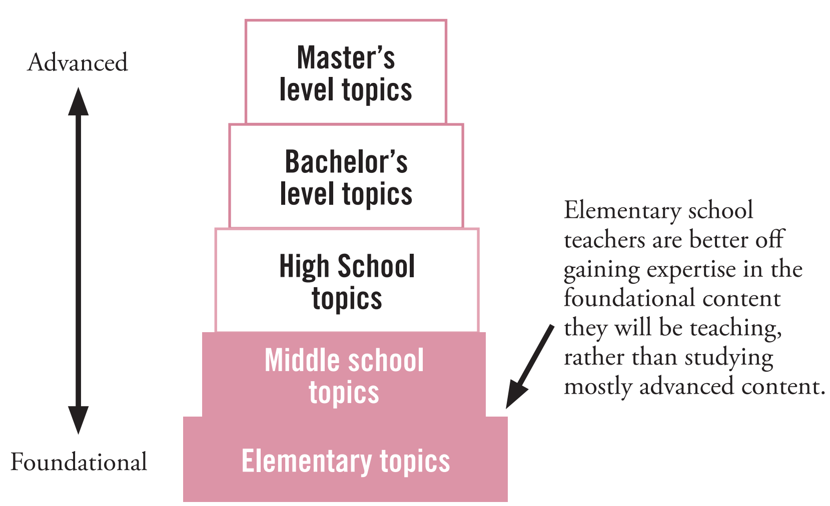
Evidence suggests that the most critical content knowledge for elementary school teachers is a "profound understanding" of the concepts taught in elementary school. A profound understanding means that teachers understand *the content they are teaching* in-depth, accurately, and without confusion.[110] This means that someone who is teaching elementary school science should understand the basic concepts taught in lower grades to a high level of accuracy. Compared to this foundational expertise, knowledge of advanced topics is not as directly useful to student learning in elementary school.[111]

For instance, elementary teachers may not need to know much about advanced science concepts like spectroscopy, but they should be experts in the concepts taught to young students, like states of matter. It is more critical for elementary teachers to have a deep knowledge of elementary concepts they will teach than a shallow knowledge of advanced concepts they will not teach.

The concept of a profound understanding has been extensively investigated in mathematics and, to a lesser extent, science and literacy.[112] While it seems clear that effective teachers should understand what they are teaching, many efforts to build teacher knowledge have focused on advanced concepts education rather than this profound understanding of the fundamental content taught in elementary school.[113]

Because of these issues, simply requiring teachers to take more subject courses or hold advanced degrees will not necessarily lead to a stronger content knowledge relevant to elementary teaching.[114] However, if required courses were

Figure 5 Elementary Teachers Need Foundational Content Subject Expertise



focused on content taught in schools – aligned to the elementary school curriculum – there might be better outcomes.[115]

2.2 Pedagogical content knowledge

Pedagogical content knowledge is knowledge of *how to teach* the content of a specific subject. Like content knowledge, greater teacher pedagogical content knowledge is correlated with greater student learning.[116]

Pedagogical content knowledge differs from content knowledge in that it involves an understanding of how students learn, how to translate a conceptual understanding into compelling examples for students, identifying and correcting student misconceptions, and being able to explain how new concepts relate to previous learning.

Pedagogical content knowledge is also specific to a given subject.[117] For reading instruction, teachers should deeply understand the process of learning to read and have an array of strategy to help young readers. In math, pedagogical content knowledge includes an understanding of how math knowledge develops in students and being able to anticipate student thinking as students approach math problems. Science teachers need to understand which instructional approaches are best for the different types of science content being taught.

Figure 6 Differences Between Content Knowledge and Pedagogical Content Knowledge

PCK differs from CK in that it requires the interaction of content with the knowledge of students and the knowledge of teaching. Teachers must be able to:

- Anticipate student thinking
- Choose the best representations
- Analyse the challenge or ease of tasks

	Content knowledge	Pedagogical content knowledge
Math	Understanding that 1⅔ is the same as 5⁄3 and how to prove that is true.	Anticipating that students might confuse the numerator and the denominator when converting fractions.
Science	Understanding the fundamental concepts of natural selection (genetic variation, heritability).	Knowing which examples best illustrate of genetic diversity and anticipating questions students may have.
Reading	Knowing what a phonemes are (units of sound that make up words).	Knowing ways to improve student phonemic awareness for literacy (the ability to notice how sounds in words work).

2.3 What should teachers learn in initial teacher education versus on the job?

There is no single place in which teachers gain all the subject expertise they need, but both the knowledge gained in initial teacher education and through in-school professional learning is important. A teacher's content knowledge can develop along a continuum, starting with a teacher's own education in elementary and secondary school, right through to professional learning activities they might undertake as a classroom teacher.[118] Pedagogical content knowledge can develop similarly, starting with an introduction to concepts in initial teacher education courses and much more learning with students in schools. The development of knowledge may not be a linear process – understanding can be revised, deepened, or corrected at many points.

Although teachers can improve subject expertise at different points, the learning environment teachers work in has a large impact on how much they develop expertise once they are teaching. Many schools in the United States do not currently have a strong professional learning environment in which to develop subject expertise. This requires teachers collaborating with subject experts, observing lessons and being observed with feedback, and continually researching best teaching methods for the subjects they teach.

In the United States, initial teacher education may actually be a critical place to develop content knowledge because teachers may have knowledge gaps from secondary school and won't have much chance to develop content knowledge once in schools.

The development of pedagogical content knowledge requires interaction with student thinking, but this doesn't mean it cannot be developed during initial teacher education. Teachers should be well prepared with pedagogical content knowledge before they are responsible for their own classroom of students. However, it is likely that pedagogical content knowledge has potential to develop much further once teachers are in schools, especially if teachers have the opportunity to participate in strong professional learning practices.

2.3.1 Initial teacher education may be a critical place to develop content knowledge

Initial teacher education is not the only place for beginning teachers to develop content knowledge, but for some systems, this may be a particularly useful intervention point. Because a great number of entrants into elementary school initial teacher education programs have poor mathematical or science skills, teacher education is an important threshold where systems can intervene.[119]

For instance, a seminal study by Liping Ma comparing mathematical knowledge in elementary teachers in the United States and China showed that while many of the Chinese teachers had only a 9th grade education, they had much stronger math knowledge than the college-educated American teachers, partially because their elementary and secondary math education was much stronger. In systems with weaker elementary and secondary education, initial teacher education could be a critical point to "break the cycle" and improve subject expertise before candidates become teachers.

> "In the vicious circle formed by low-quality school mathematics education and low-quality teacher knowledge of school mathematics… teacher preparation may serve as the force to break the circle."
>
> Ma, 1999

For many teachers, their initial education may be one of the few opportunities in their career where they have the time, support, and resources to learn content in a comprehensive way. The empirical base is weak, but some studies suggest that in-service teachers do not continue to develop their content knowledge substantially once they are in the classroom, and that the teaching experience is not sufficiently conducive to learning content.[120]

Teacher education is a forum where false beliefs, areas of weakness, and uncertainties can be explicitly addressed. A substantial body of research, mainly conducted by teacher educators teaching content courses, suggests that specific content courses in initial teacher education can vastly improve teacher knowledge.[121]

There is good evidence that targeted interventions can dramatically improve teacher content knowledge, at least in the short term.[122] However, there are few longitudinal studies of how well knowledge acquired in a single initial teacher education course is retained over time.

Ideally, teacher professional learning policies in schools will also foster the development of deep content knowledge. Indeed, Ma's study found that much of the Chinese teachers' strong knowledge was developed through intense professional learning in school.[123]

2.3.2 Exposure to student thinking is important for pedagogical content knowledge

There is limited agreement about how much *pedagogical* content knowledge can be developed in initial teacher education. It seems that new teachers rapidly develop pedagogical content knowledge in the early years of teaching, due to their intensive exposure to student thinking. Some teachers may also benefit from exposure to the professional learning community within their schools and between their school and other schools. In these early years of teaching, teachers also gain general pedagogical skills (such as classroom management).

However, there have been substantial efforts to document ways to build pedagogical content knowledge in initial teacher education. These include undertaking practicums, the use of microteaching, video lesson observations and discussion, and mock lesson planning. Many of these have been found to have positive impacts on preservice teacher pedagogical content knowledge.[124] Exposure to student thinking is considered to be an important part of developing pedagogical content knowledge, and arguably to content knowledge, most relevant to student learning.[125]

3 What is Known About Mathematics, Science, and Literacy Teacher Knowledge?

3.1 Mathematics

3.1.1 Mathematics content knowledge

The U.S. National Mathematics Advisory Panel states, "It is self-evident that teachers cannot teach what they do not know."[126] Teachers need a strong, coherent grounding in fundamental mathematics as it is taught in elementary school.[127] Unfortunately, this is not being reliably taught in many initial teacher education programs in the United States.[128]

In elementary school, students generally learn the basics of two branches of mathematics: arithmetic and geometry.

Ideally, elementary school teachers would take courses to develop a deep understanding of these areas of math rather than mainly taking advanced math courses (e.g., calculus) that may not be directly relevant to elementary curriculum. This would mean a focus on using mathematical expressions like number equations and other visual representations to show the relationships among quantities in a problem and the steps in a solution. The use of visual representations should be developed into deeper and deeper understanding of number lines from which graphing is built in algebra. The properties of operations (commutative, distributive) that govern number equations are the same for whole numbers, fractions, and variables in algebra; teachers should understand this deep coherence between arithmetic and algebra.[129]

A focus on these areas would better enable teachers to understand elementary mathematics to a level where they can explain *why* a certain thing is so.[130] Frequently, this means having an understanding of the underlying mathematics, rather than merely being able to show steps and give examples.[131]

For instance, understanding that a fraction is a number means that the properties already understood for whole numbers extend to fractions. The arithmetic of fractions is a coherent extension of whole number arithmetic and extends, in turn, to expressions with variables in algebra. If teachers understand that a fraction is a number with the same properties of other numbers, they can help students understand this idea to improve their understanding of fractions.[132] In order to use precise mathematical language in the classroom, teachers need a strong grounding in the underlying conceptual framework of elementary mathematics.

3.1.2 Mathematics pedagogical content knowledge

In elementary mathematics, there are often dozens of ways to conceptualize and perform the same kinds of procedures. Therefore, teachers need to grasp the underlying rationale behind a range of these concepts and be able to interpret whether students are understanding what they are learning.

For instance, there are dozens of ways of correctly "doing" multidigit multiplications, not all of which illuminate the mathematics at work. A teacher should be able to check whether students' methods for solving a problem work, and to identify how going through one particular example would

Box 2 Teacher Confidence Affects Math Learning

Weak mathematical skills are sometimes manifested in "math anxiety," where individuals fear learning and teaching mathematics, often as a result of poor math education in their own schooling.[133] Teachers who are not confident in teaching mathematics also teach it less, and therefore students learn less. There is substantial evidence that well-designed math courses can help lessen math anxiety, and build solid mathematical understanding.[134]

In the United States, there is a strong gendered element to math anxiety, where female teachers' beliefs about their mathematical ability negatively affect girls' mathematical learning.[135]

improve or impede student learning in a given situation.[136]

For example, a teacher introducing multidigit multiplication for the first time might present the problem 52 × 14 and ask students for ideas on how to solve it based on their previous learning. Prior to the lesson, the teacher should be able to list the different approaches students might take and decide which ones work and which ones do not and why not. Then in class, the teacher should be able to decide which approaches she should dive deeper into to improve whole-class understanding, and which approaches might be less useful or confusing to discuss with the whole class.

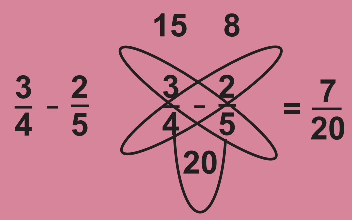
Teachers need to not only ensure student success with current grade level content but teach for deeper understanding that lets students better understand content in later grades. This involves knowing when teaching a “shortcut” or “trick” is likely to hinder later student understanding.

For instance, it seems that many United States students have a particular weakness for mathematics tasks with higher cognitive demands, such as taking real-world situations, “translating them into mathematical terms, and interpreting mathematical aspects in real-world problems.”[137] On the PISA test, U.S. students are strong at using a formula provided and doing easy calculations, but they have problems with establishing equations themselves when given situations.[138] This suggests that U.S. students are experienced in doing calculations and getting answers, but they do not have a strong understanding of what different variables in formulas mean and why calculations work. This significantly limits the ability to apply knowledge and understand advanced mathematical topics.

Students may have learned procedures to generate a correct answer, which fails at higher levels of math.[139] As one review put it, “students often are taught computational procedures with fractions without an adequate explanation of how or why the procedures work.”[140] Many studies of teacher math knowledge find their knowledge is limited to performing procedures, and does not extend to deep conceptual understanding.[141]

Box 3 An Example of the Importance of Pedagogical Content Knowledge in Mathematics

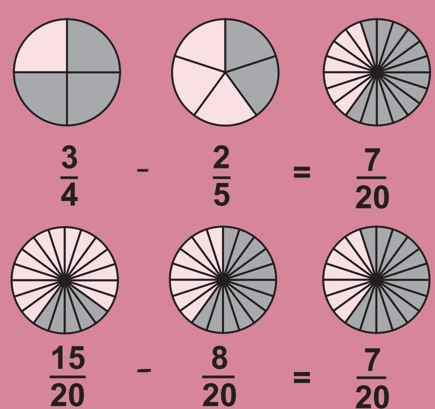
Teachers often use the invert and multiply method to teach fraction addition, yet few can explain why the procedure works.[142]



With this method, students are taught a procedure that generates an answer but has no connection to the underlying mathematical concept of whole numbers.

A better approach to adding fractions is to use representations to aid student learning.

In this approach, students still need to find a common denominator, but they can clearly see what they are trying to do. An example with a representation like this could have a real world example (such as dividing a pizza) that would help students conceptualize dividing the pieces to create a 'common denominator'.[143]



Many teachers are not currently equipped with this knowledge or related knowledge.[144] For example, a study by Thanheiser (2009) found that two-thirds of prospective elementary teachers conceptualized numbers incorrectly and were unable to understand the concept of regrouping.[145]

3.2 Science

3.2.1 Science content knowledge

At the elementary level, science typically involves both an introduction to scientific reasoning (such as experimentation and the scientific method), as well as a broad variety of content. Concepts such as patterns, cause and effect, and stability and change are introduced. Many topics, including organisms, planets, and energy, are covered.[146]

The concepts taught in elementary science are broad and span a variety of disciplines. To help students learn, teachers need grounding in a wide range of scientific content as well as an understanding of how scientific knowledge is hypothesized, generated, and interpreted.

Teachers must be able to go beyond "common sense" ideas about the world, as many fundamental and essential scientific ideas (e.g., states of matter, gravity, evolution, space, atomic structure) resist simple observational and inferential methods. Incomplete beliefs resulting from untutored observation persist across society, such as the idea that some things are inherently cold or hot, or that evolution is the result of species "trying" to adapt, or that when a substance burns or evaporates it "disappears."[147]

The specific content knowledge required by elementary science teachers has been less researched than that required by mathematics teachers. A strong understanding of the core ideas in elementary science appears equally important for teachers,[148] and similar to math, many preservice teachers lack this knowledge.[149] As in mathematics, proxy measures such as number of courses taken or teacher self-confidence are often poor measures for actual knowledge.[150]

3.2.2 Science pedagogical content knowledge

Student performance in science is higher when teachers have more science pedagogical content knowledge.[151] So teachers with weak science pedagogical content knowledge have less effective pedagogical practice. How does this play out in the classroom?

This impacts some students more than others. Teachers with weak science pedagogical content knowledge often prioritize students enjoying science and conducting activities, without a connection to scientific thinking that will truly deepen student understanding of science. This has a profound impact on student learning. Some elementary school students do not advance to higher levels of performance like they should, and many fall behind as they do not truly understand the foundational scientific concepts required to be successful during middle and high school.

A number of key reports such as the National Academies' *Taking Science to School and A Framework for K-12 Science Education: Practices, Crosscutting Concepts and Core Ideas* (which led to the Next Generation Science Standards) illustrate effective science teaching.

Students bring a mix of scientific conceptions to class with them, as well as "reasoning abilities [that] are constrained by their conceptual knowledge, the nature of the task, and their awareness of their own thinking."[152]

For students to advance their scientific understanding, teachers need to understand the breadth and diversity of students' science conceptions (and misconceptions) in their classrooms and implement pedagogies to deepen conceptual understandings and unpack misconceptions. These pedagogies include engaging students in scientific reasoning and practices, using a range of instructional practices (i.e., explicit and inquiry approaches), quality formative assessment, and including the "scientific method" as one approach among others for inquiry.[153] More broadly, science teachers need to use approaches to learning science that are themselves scientific, such as forming hypothesis, developing the right questions to ask, and analyzing data.[154]

Understanding and confronting student preconceptions

An understanding of student scientific conceptions is an important component of pedagogical content knowledge and perhaps the aspect that has been most studied, with many studies showing teachers share similar incomplete understandings to students.[155]

For example, adults and children alike often share incomplete understandings about basic aspects of lunar phases and the causes of the seasons. Commonly, people believe that the moon's phases are the result of the earth's shadow on the moon.[156] Many people also believe that seasons are caused by the distance of the earth from the sun due to an elliptical orbit (rather than the earth's axial tilt).

The best way to combat misconceptions like these is

- designing and implementing activities that explicitly confront the misconception,[157]
- choosing texts and materials that promote cognitive conflict, and
- encouraging students to revisit their conceptions.[158]

Strong pedagogical content knowledge will allow teachers to set up a line of questioning that reveals and completes the partial understanding.[159] For example, a teacher could ask what the difference is between an eclipse and a new moon, or why it can be summer in some parts of the world and winter in others.

Inquiry-based methods

Science pedagogical content knowledge is particularly important in the context of inquiry-based pedagogy. Inquiry pedagogy is often emphasized in elementary school science education. However, teachers who are not prepared with enough subject expertise who use inquiry-based pedagogy may limit student learning.[160] Teachers need to ensure that inquiry methods are strongly connected to the content in order to be effective. This means teachers must have the pedagogical content knowledge to set inquiry up in a way that drives students to the learning goal. Pedagogical content knowledge also helps teachers lead reflection discussions after inquiry to ensure students have the opportunity to consolidate their learning and complete any partial understandings.

One issue that makes inquiry instruction difficult is that many aspects of science are not obvious purely through observation, and teachers need to be aware of which topics inquiry-based teaching is useful for and which ones require other instructional methods.

For instance, the idea of gravity is easily understood in reference to an object falling to the ground, but it is less obvious that gravitational forces exist when objects are not in motion. Teachers need not only to understand the idea of "gravity" at a theoretical level but to be able to explain that it is always present and affects everything with a mass, and find ways to show this.[161] This may sound obvious but it is far from simple in the classroom. It requires extensive elementary science pedagogical content knowledge.

3.3 Literacy

Teacher knowledge in reading and literacy is not as well studied as in math or science.[162] While there is not a strong research base for deciding the necessary components of teacher knowledge for teaching reading, there is growing consensus around many of the key elements that can provide a starting point.[163]

This report offers a short summary of the existing evidence for teacher subject expertise in literacy. For in-depth information, see these publications:

- C. Snow, Griffin, & Burns, 2005
- National Institute of Child Health and Human Development, 2000
- International Reading Association, 2007

3.3.1 Literacy content knowledge

Many might believe that there are more obvious teacher content knowledge gaps in math and science than in reading, assuming that all teachers know how to read. However, teaching reading requires considerable content knowledge and pedagogical content knowledge.[164] Adults can be fluent readers without the deep knowledge of language and reading process that is necessary for reading instruction.

For example, understanding how letters can sound differently in different words helps teachers choose which words are best to present in a lesson and to identify student errors. Most adult readers would not normally recognize that the *t* in *little* can sound like a *d* and is different than the *t* heard in *top* and *hit*, but for a teacher it means they are able to anticipate student spelling and reading issues.[165]

Competent reading requires a fluency – or smoothness – that doesn't allow most people to stop and think deeply about word sounds and language patterns. Strong teacher content knowledge requires an unpacking of ideas that makes knowledge that seems "easy" quite complicated.

What teachers need to know

Teachers need to develop knowledge across a number of dimensions to teach reading instead of having just general reading skills. It is possible to look at the type of knowledge required in two categories: language comprehension knowledge and word analysis knowledge.[166]

Language comprehension: Comprehension is the ability to read text and understand its meaning. It is complicated and requires not just explicit knowledge but also skill in metacognition (awareness and monitoring of understanding).[167] Understanding reading comprehension requires knowledge of things like vocabulary, morphology, genre, and reading fluency.[168] It also requires text analysis skills – being able to identify what background knowledge is needed to understand the text.

Word analysis: Readers benefit from opportunities to learn about language and text elements that make up words.[169] Teachers must have this knowledge themselves if they are to best help students. This knowledge includes things like phonemic awareness, letter sound relationships, and ability to decode unfamiliar words.[170]

Teachers also need to be familiar with the technical terms for literacy that feed into word analysis and language comprehension knowledge.[171] These terms provide good examples of the types of content knowledge that are specific to teaching reading and that are not typically known by other adults. For example, the term *phonology*, which is related to word analysis and refers to understanding the system of sounds that make up language. Similarly, the term *orthography* refers to understanding the conventions for how to write a language – including spelling, capitalization, and punctuation. Literacy teachers with strong content knowledge can use their knowledge of these conventions to help students with comprehension and writing.

3.3.2 Literacy pedagogical content knowledge

Literacy pedagogical content knowledge builds on teachers' content knowledge and requires knowledge of the process of learning to read, difficulties students may encounter, and research on the effectiveness of various pedagogical strategies. For example, teachers need pedagogical content knowledge to understand what words or expressions in text might be unfamiliar to students. Teachers need to know that some words, e.g., 'who', do not follow the rules of phonics and cannot be sounded out. Teachers also need to understand that some children may be experiencing learning difficulties, such as dyslexia, and how to identify this.[172]

Pedagogical content knowledge for literacy includes understanding when students should be expected to develop certain literacy skills. Teachers might recognize that being able to count syllables in a word is a first-grade accomplishment, and using roots to infer word meanings is accomplished in third grade. This type of knowledge helps teachers accurately identify when student mistakes are normal for their age, when the teacher should plan an intervention to prevent students from falling behind, or when a student might require specialist assistance.[173]

Along with knowledge of student development, pedagogical content knowledge also involves understanding which instructional approaches are helpful for students at each developmental level.

In 2000, the United States-based National Reading Panel published a report that reviewed more than 100,000 reading studies on how children learn how to read. Although the evidence was sparse,[174] the report made clear that teachers need to be knowledgeable about the following best approaches to reading instruction:[175]

- **Systematic teaching of phonemic awareness:** teaching students that words are made up of smaller sounds (phonemes)
- **Explicit phonics instruction:** making sure students connect sounds with letters; are able to sound out words
- **Guided oral reading to improve fluency:** monitoring how easily students read words; helping them read with speed, accuracy, and expression
- **Teaching vocabulary words** directly and indirectly through text or separately
- **Comprehension:** giving students strategies to understand what is being read across multiple text genres; e.g., having students summarize what they've read

Worryingly, some analysis has shown that a large portion of initial teacher education programs in the United States – up to 30 percent – may not be including these approaches in early reading teacher education programs.[176]

English language learners and struggling readers

It is valuable for teachers of English language learners and struggling readers to have specialized knowledge of how to best help students. Given that most elementary school teachers will have some students with specialized learning needs, it seems obvious that all teachers should be prepared with this knowledge.

For example, the following knowledge may be important for teachers of English language learners:[177]

- Knowledge of second language development
- Understanding individual differences among the wide range of English language learners
- The connection between language, culture, and identity

While the majority of teachers teach students with disabilities, few feel well prepared to meet their needs.[178] Teachers may subscribe to certain myths about students with disabilities, such as the idea that reading instruction needs to be significantly different for these students. However, the instructional needs of struggling readers are very similar and studies have found they can reach the same level of reading achievement.[179]

More generally, it is important that teachers pay close attention to the texts students are exposed to and the background knowledge these texts presuppose. Teachers need to critically review texts to determine whether they contain words or expressions that are likely to be unfamiliar to all or some students, or used in unfamiliar ways.[180]

3.4 Conclusion to Part I

The types and level of knowledge that elementary teachers need is a matter of surprisingly little high-quality research. What emerges from the research landscape is that teachers need to have strong subject expertise, consisting of a deep understanding of the concepts they are teaching and the ability to teach this content to students.

With the limited empirical base, policymakers cannot make decisions on literature alone. Therefore, it is helpful to look to systems that are known for having a high level of teacher subject expertise for policy insights.

Part II of this report looks at how Japan, Finland, Hong Kong, and Shanghai ensure their elementary teachers have a high level of content knowledge and pedagogical content knowledge. These systems are not identical, but they share many commonalities in how they carefully select, prepare, and continually develop teachers with some of the strongest subject expertise in the world. The next section examines policies to support elementary teacher learning during and after initial teacher education, and how schools, policymakers, and teacher education institutions can develop subject expertise to support student learning.

Part II: Policies: Lessons from Japan, Finland, Shanghai and Hong Kong

4 Selection

One way for systems to improve teacher subject expertise is to assess candidates and select only those prepared with the greatest knowledge.

The United States currently attempts these assessments mainly through teacher licensure exams. While there are some clear exceptions, they are often not considered rigorous.[181] Outside of the point of licensure, it is rare for a teacher candidate to have an assessment of subject expertise. Most initial teacher education programs do not set rigorous entry or graduation requirements,[182] and most school districts do not assess teacher knowledge when making hiring decisions.

High-performing systems look very different in their assessments of teacher subject expertise. For example, Finland has a challenging initial teacher education admissions exam that assesses both current expertise and potential to learn. Japan has comprehensive employment exams that test teacher subject knowledge with a paper exam as well as through a demonstration lesson. In these systems, teacher candidates are required to meet a high standard of cognitive ability, academic preparation, and subject expertise before they are accepted as full classroom teachers.

Selection assessments must be rigorous

Having rigorous tests of teacher subject expertise is not a new idea. In the United States, in fact, subject expertise assessments have been used for over 100 years and they used to be quite rigorous. One elementary teacher exam from 1875 tested 20 subjects, including mental arithmetic, physics, orthography, and even industrial drawing.[183]

Currently, there are hundreds of teacher licensure exams in the United States that attempt to assess subject expertise, but the bar for passing these exams is often set very low. This is not always caused by the design of the assessment itself, but by the cut scores (the minimum score necessary to pass) that are set by states. One of the most common exams, the Praxis, is taken in 39 states and each state sets different cut scores for the same exams.[184] The majority of states set the passing bar very low, at or below the 16th percentile–ensuring that virtually all candidates pass.[185]

U.S. licensure exams are seen as setting the minimum bar for entry into the profession, not as a method to identify the best talent. States worry about raising the bar for fear of teacher shortages, and it is politically difficult for states to justify their rationale for such changes.[186]

Most high-performing systems do not have such a heavy focus on licensure exams and instead focus on assessments elsewhere on the teacher development pathway. These systems have rigorous assessments at points like admission to initial teacher education or employment, where spots for candidates are limited in a way that doesn't occur during licensure. There is no natural limit to the number of teachers who can be licensed, but there is a limit to the number that can be employed or admitted to a teacher education program. This creates a forced-ranking system with naturally more rigorous standards, where only the candidates with the greatest subject expertise are admitted or hired.

Selection can occur at multiple points along the teacher development pathway

Many in the United States are worried about declining expertise of elementary teachers. There are few measures of teacher expertise (knowledge and skills), but there are examples of declines in the standard of graduates being accepted into teacher education. Much has been made, for example, that while some systems such as Finland only let top high school graduates into teacher education, teacher education in the United States is less selective and teachers generally come from the lower half of college graduates.[187]

But it is a mistake to therefore assume that the only place to put in entrance hurdles is at the entry point into initial teacher education. Effective reform is much more nuanced. The reality is that there are multiple points to assess potential teachers along their development pathway and each has its pros and cons.

High-performing systems outline a number of the points at which an education system can create a selection filter – or assessment of teacher knowledge – to ensure beginning teachers are adequately prepared.

Points along the pathway where assessments of teacher knowledge can be used for selection include:

- **Entrance to initial teacher education** – using results in high school, exams, and interviews on admittance to initial teacher education
- **Exit from initial teacher education** – exams and demonstrations of teaching ability before graduation
- **Licensure and certification** – requirements to be licensed or certified as a teacher (usually set by a government)
- **Hiring** – schools can use their own assessments of pedagogical content knowledge and content knowledge to select teachers to be hired
- **Induction** – probationary periods and requirements for full teacher status.

Assessments of teacher subject expertise should assess actual expertise, not proxies

How elementary teachers' subject expertise is assessed is vitally important for effective reforms to develop elementary teachers. Too often, past efforts have focused on the wrong things: teachers' degrees held or years of experience, rather than testing their actual skills and abilities. This is an issue because it is not always the case that teachers doing more subject (e.g., math) courses improves their subject expertise. Not all courses are equal, and degrees with the same name can vary widely in quality.

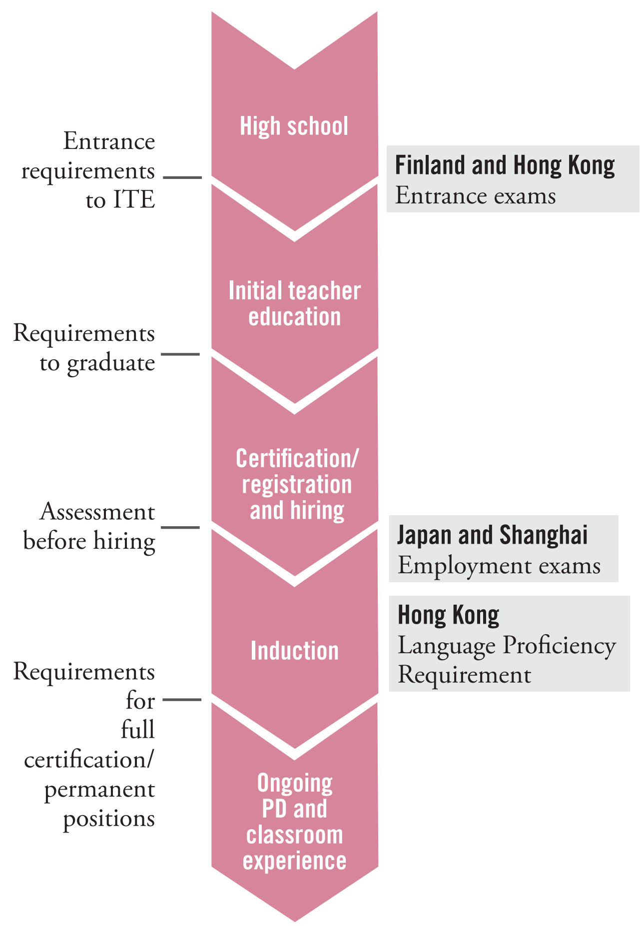
There are much better ways to more directly assess teachers' subject expertise. High-performing systems show how these assessments can be used to ensure only high-quality teachers enter classrooms *and* lead to improvements throughout the system of teacher education and development.

4.1 Selection early in the pathway

Many education systems, including Finland and Hong Kong, have a rigorous process for selecting only the best candidates early on in the teacher development pathway. In these systems, there is usually a high bar for entry into initial teacher education and fewer assessments of teacher knowledge further down the pathway.

A strong emphasis on early pathway selection seems to work well in systems with government-funded initial teacher education places that are limited to demand for new teachers, also known as having quotas or "capping" initial teacher education places. Hong Kong and Finland have this in common: the number of initial teacher education providers and teacher education places are mostly centrally controlled.

Figure 7 Selection Points Along the Teacher Development Pathway



Finland has only eight teacher education providers, and Hong Kong has four that are government-funded (one other initial teacher education provider is self-funded). Each of them has capped admissions based on government projections of the required teacher workforce.

Where total supply of new teachers is limited like this, it essentially forces the selection to come at the front of the pathway in initial teacher education. It makes sense that with limited initial teacher education spots, there will be much more selectivity on entrance to initial teacher education.

4.1.1 Finland has a comprehensive initial teacher education admissions process

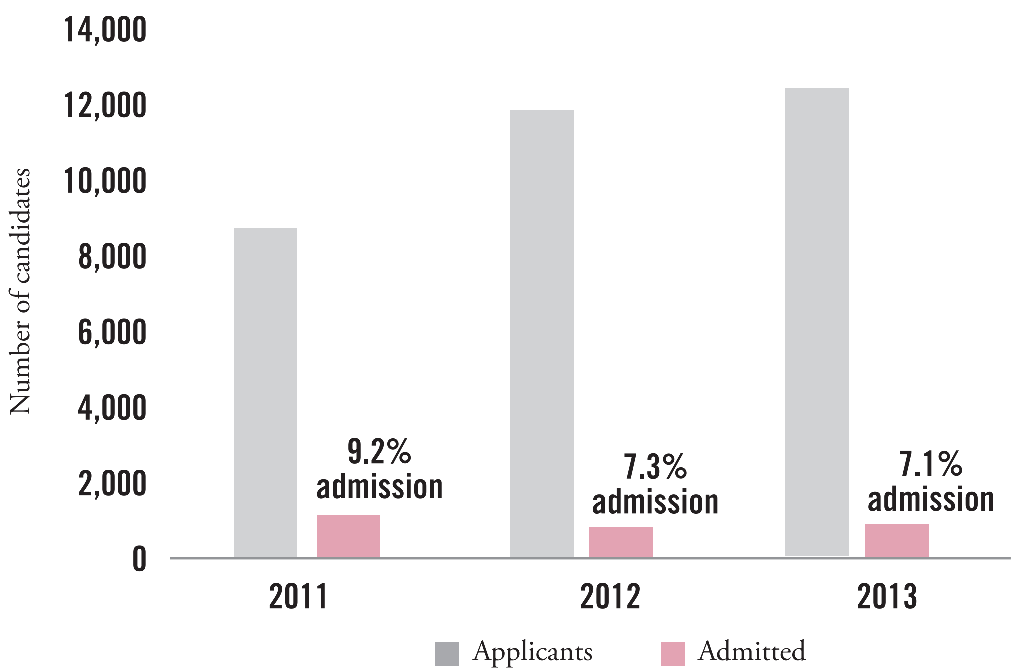
Finnish teachers have some of the highest cognitive skills in both literacy and numeracy in the world.[188] They come from the upper part of the skill distribution, with a highly competitive initial teacher education admission process – less than 10 percent of applicants are admitted each year.[189]

Since selection of candidates occurs before they have taken any teacher education courses, the selection assessment is focused on the potential of candidates to learn, not just on their current knowledge. The Finnish teacher education programs do look at subject expertise through analysis of high school grades, but they do not have a paper test of skills in each subject. Instead, most programs have candidates take the VAKAVA exam, which requires reading of various research studies and test questions about the literature. This exam primarily tests research skills, which shows the potential of students to learn during initial teacher education. The exam also indirectly tests literacy, science and math skills.

Selection process

Teacher candidates go through a rigorous, multistage admissions process when applying to initial teacher education. Each of the eight initial teacher education providers are authorized to decide their own selection criteria. However, there

Figure 8 Applicants vs. Admissions for Elementary Initial Teacher Education Programs in Finland[190]



Source: Finland Ministry of Education and Culture, 2014 is coordination, especially for the first parts of the admission process.

Aspiring teachers can apply simultaneously to multiple universities through a selection cooperation network of universities, called VAKAVA.

Candidates then sit the VAKAVA examination, which involves a series of multiple-choice questions based on academic material published approximately six weeks before the exam. The material and examination are highly challenging, with points deducted for incorrect answers or nonresponses. Content on the 2015 exam included (among other topics)[191]

- distinguishing between methodological approaches in social research,
- education theory,
- interpreting regression analyses, and
- analyzing psychological research, among other topics.

The next phase of admissions varies by university, but generally candidates will do a sample lesson and participate in an interview.

See sample VAKAVA exam questions on next page and in the Appendix.

Attraction to the profession

Admission standards are one form of selection into teaching but self-selection by candidates is also important to take into account. Making teaching an esteemed, respected profession will enable it to compete for the best students with law, medicine, and other highly regarded professions.

Many high-performing education systems that have selective entry requirements into initial teacher education also have made teaching a highly attractive profession.

Critically, higher pay relative to other professions is correlated with higher teacher skills throughout the OECD.[192] However, other factors aside from pay can influence the attraction of the profession, including good working conditions and high professional status.[193] Without raising salaries, working conditions or the status of teaching as a profession, admission standards will only eliminate the very bottom rather than improve the overall pool of candidates.

Much of the reason that Finnish initial teacher education programs can be so selective is because the profession is highly attractive. Teachers in Finland do not earn a particularly high salary, but it is not too low either. Finnish teachers earn 73 percent of what similarly educated workers make, which is just below the OECD average of 78 percent, but above the United States, where teachers earn between 65 percent and 70 percent of what college-educated workers earn.[194] Other factors, such as the social prestige of the profession and professional autonomy, might matter more for those choosing to enter a teaching career in Finland.[195]

Box 4 An Example of a VAKAVA Exam Question

The VAKAVA exam includes a series of multiple-choice questions based on academic material published approximately six weeks before the exam. Candidates read academic journal articles and answer questions.

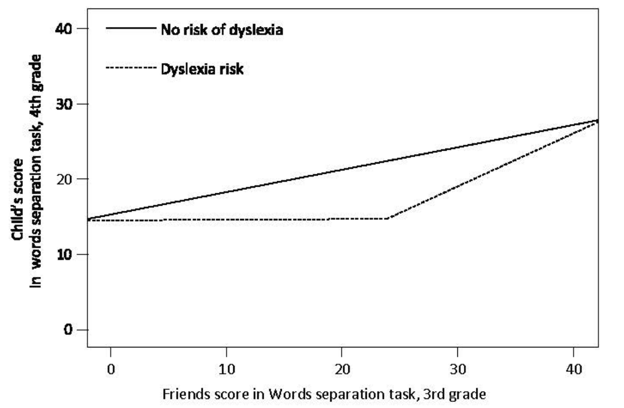


Figure 1. Child's dyslexia risk as a changing factor: The connection between the friends score and the development of the child's score in Word separation task from 3rd grade to 4t grade.

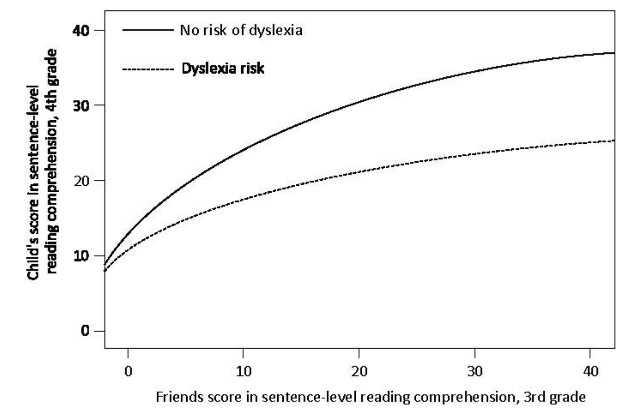


Figure 2. Child's dyslexia risk as a changing factor: The connection between friends score and the development of the child's score in reading comprehension from 3rd grade to 4th grade.

Sample question: Figures 1 and 2 have been obtained by a study by means of regression analysis. Below are statements relative to the interpretations. Select one of the following options for each interpretation:

1. Children with a dyslexia risk develop slower from third grade than those who do not have a dyslexia risk, according to a test measuring the separation of words. When entering fourth grade, the difference between groups has evened out.

   A) Compatible only with figure 1
   B) Compatible only with figure 2
   C) Compatible with both figures
   D) Not compatible with either figure

2. The difference between children with dyslexia risk and without dyslexia risk in children's reading comprehension increases strongly when entering the fourth grade.

   A) Compatible only with figure 1
   B) Compatible only with figure 2
   C) Compatible with both figures
   D) Not compatible with either figure

3. The higher the score in understanding sentence-level reading a child's friend has in the 3rd grade, the less the friend's score affects the child's own sentence-level reading comprehension.

   A) Compatible only with figure 1
   B) Compatible only with figure 2
   C) Compatible with both figures
   D) Not compatible with either figure

More sample questions available in the appendix.

Source: "VAKAVA exam – Questions and correct answers," 2015
Answers: 1.D, 2.D, 3.B

4.1.2 Hong Kong has high admission standards for each subject

Hong Kong's five teacher education providers are able to set their own admissions criteria and process.

At the Hong Kong Institute of Education (HKIEd, where 84 percent of Hong Kong's elementary school teachers have studied),[196] there are several selection methods in place to select high-quality entrants.

First, HKIEd sets minimum high school scores for entrance into its undergraduate programs, but usually selects students with scores much higher than the minimum.

In 2015, the entering cohort of prospective teachers seeking to major in English, Chinese or Mathematics required a top score in the selected subject.[197] English majors had to be in the top 10 percent, Chinese majors in the top 8 percent, and math majors in the top 14 percent of all high school students.[198]

Academic results are supplemented with a test and an interview process in many cases. For instance, at HKIEd, applicants for the Bachelor of Education in English Language – Primary undertake a one-hour written test and have a 15-minute interview with two lecturers (in a group of three prospective students).[199]

HKIEd also has language exit requirements for all teachers, with students needing to demonstrate proficiency in both English and Chinese (Mandarin).[200]

4.1.3 Hong Kong Language Proficiency Requirements

In the mid-1990s, Hong Kong businesses and government became concerned that students were not graduating with appropriate language skills and started plans to step up the language skill requirements for all teachers. In 2000, the government announced that all teachers must meet language requirements for Mandarin (also called Putonghua) and English – languages representing a major goal of the Hong Kong elementary education system.[201]

All existing in-service teachers of Mandarin and English were required to meet a Language Proficiency Requirement (covering various aspects of proficiency in these languages) by 2007.[202] New teachers joining the profession were required to meet the requirement within two years. Those that didn't meet the requirements could not teach language subjects.[203]

The Language Proficiency Requirement can be met by passing the Language Proficiency Assessment for Teachers, administered by the Education Bureau. The requirement can also be met by graduating from an approved program in a university that has provided sufficient assurance of language proficiency.[204]

According to the Education Bureau, the language proficiency levels 'provide an objective reference against which teachers' proficiency can be gauged to help them pursue continuous professional development'.[205]

Content of the assessments

The assessment for English comprises tests in reading, writing, listening, and speaking. For Mandarin, the assessment consists of tests in listening and recognition, pinyin (transcription of Chinese characters into the Latin alphabet), and speaking. After meeting the Language Proficiency Requirement in these areas (typically before being hired), beginning Mandarin and English teachers also complete a Classroom Language Assessment, which consists of a lesson observation to observe their language skills in the classroom.[206]

The tests are rigorous and demanding, requiring nuanced understanding of the language. For instance, in the 2-hour writing component of the English Language Proficiency Assessment, teachers are asked to write a 400-word narrative, rewrite a student composition, and write explanations of frequent errors.

The Language Proficiency Assessment is challenging, with clear differences emerging between the different parts of the assessment. The proficiency rate for reading in English in 2015 was 87.8 percent, while the proficiency rate for speaking in English was 54.8 percent. In Mandarin, speaking ability was stronger with 72.5 percent meeting

Box 5 An Example of a Teacher Meeting the Minimum Standard in English Language Proficiency

The following is an example of what is considered a minimum standard in writing to meet the English requirement in response to the above prompt. This example was drawn from the annual report published by the Education Bureau.[207]

Task: *You have been asked to write a short article of about 400 words for a youth club magazine describing different relationships you have encountered as a young professional. Describe at least three people in your life with whom you have very different relationships. Explain how these relationships are different.*

Teacher response: *"There are different roles we have to play in our whole lives, such as 'student,' 'brother,' 'daughter,' or even 'mother' in the future. It is impossible to have the same kind of relationship with every person that you meet in your daily life. As a young professional, I would like to share my experiences, talk about three people in my life whom I have very different relationships and explain how they are different.*

"The first person that I am going to talk about has a very close relationship with me. She is my elder sister. My sister is only two years older than me, so we have no communication problems at all. We have similar characters, similar hobbies and even the same idol. We were in the same primary and secondary school, thus at that time, we always chat with each other for hours after school, talking about what had happened that day and what funny jokes the teachers had said. We share secrets, happiness and also things that upset us. Therefore, we have very close relationship…"

proficiency, but listening was comparatively worse, with only 53.7 percent of prospective students meeting this benchmark.[208]

4.2 Selection later in the pathway

Many countries fund and regulate initial teacher education providers very differently than Finland and Hong Kong, with open initial teacher education systems that allow for unlimited providers and student places. In these systems, the provision of initial teacher education has proliferated in recent years. With hundreds of initial teacher education providers, reforms to increase entry standards or to regulate initial teacher education quality become more difficult both in terms of policy design and political realities. Therefore, open initial teacher education systems with many providers might find it easier to structure strong assessments of teacher knowledge later in the pathway – at certification, employment, or once in schools.

Initial teacher education providers are often universities with a large degree of autonomy. They are not easy for governments or systems to control. This becomes even harder when teacher education is profitable and seen as a "cash cow" for universities. There is an incentive for providers to get as many enrollments as possible. Even if governments can generate the political will to mandate higher entry requirements, providers might develop workarounds to continue to enroll students anyway.

System leaders might therefore be more interested in targeting assessments of teacher knowledge at later stages of the teacher development pathway. Improving selection criteria at employment might be a particularly effective way to improve the teacher workforce.[209] These assessments not only ensure candidates are well prepared but also signal to initial teacher education providers expectations for graduate teachers.

Selection done through candidate ranking may be more effective than just setting a minimum bar

Many systems, including the U.S. system, invest in candidate assessments at teacher certification. Certification assessments set minimum standards for teachers and ensure that the least knowledgeable candidates aren't in classrooms. This is important, but the minimum standards approach may have two issues: (1) it does not create incentives for development past minimum standards, and (2) it does not provide differentiating information to the system on teaching candidate quality (aside from binary pass-or-fail data).

When the assessment ensures teachers (or teacher candidates) meet minimum requirements, actors in the system target minimum standards. Teacher candidates prepare themselves to pass minimum standards, initial teacher education providers design the courses and set quality benchmarks to ensure minimum standards are met. And schools then only employ teachers who meet the minimum standards.

On the other hand, an assessment with a continuous measure of teacher expertise (or one that ranks candidates) focuses candidates on developing the strongest expertise possible. Initial teacher education providers know they must develop deep expertise in all of their teachers. Schools can more easily differentiate between candidates with more information on which teachers have the greatest expertise. If candidate assessment data is made transparent, it provides a serious incentive for the initial teacher education providers and helps teacher candidates make decisions about which program to attend.

Teacher certification is part of the pathway most prone to having assessments based on minimum standards. This is because there is no limit to the number of teachers that can be certified: if all candidates meet the minimum bar, all can become certified. But there are limits to the number of teachers employed or the number accepted to initial teacher education. This is why rigorous selection assessments at employment that rank candidates can be powerful, particularly when the supply of teachers is much greater than the demand.

4.2.1 Japan has rigorous employment exams for all teachers

Japan has an open initial teacher education environment with over 1,000 providers. The majority of institutes of higher education – of which there are hundreds – have teacher training courses.[210] Because of the large number of providers, admissions criteria vary significantly. This can pose problems and does so in many systems that have concerns about quality of courses and teacher candidates. However, Japan has a very rigorous process of selection later in the pathway – at the point of hiring.

In Japan, graduates of initial teacher education programs must pass one or more employment exams set by the prefectural board of education they are seeking employment with. These exams are often created and administered by a team within the prefectural education office, though some prefectures use external consultants and companies to create the exams.[211] Different aspects of teacher aptitude can be tested, and exams may include demonstrations (e.g., in physical exercise, music, arts and crafts, and in foreign languages), microteaching, and preparation of lesson plans, interviews, and essays, as well as written examinations.[212]

For example, the Saitama prefecture prepares and conducts the exam with a staff of about 15 who work on it full-time and many others who are involved part-time or in an advisory capacity. The employment exam for elementary school teachers covers content up to 10th grade in all subjects.[213]

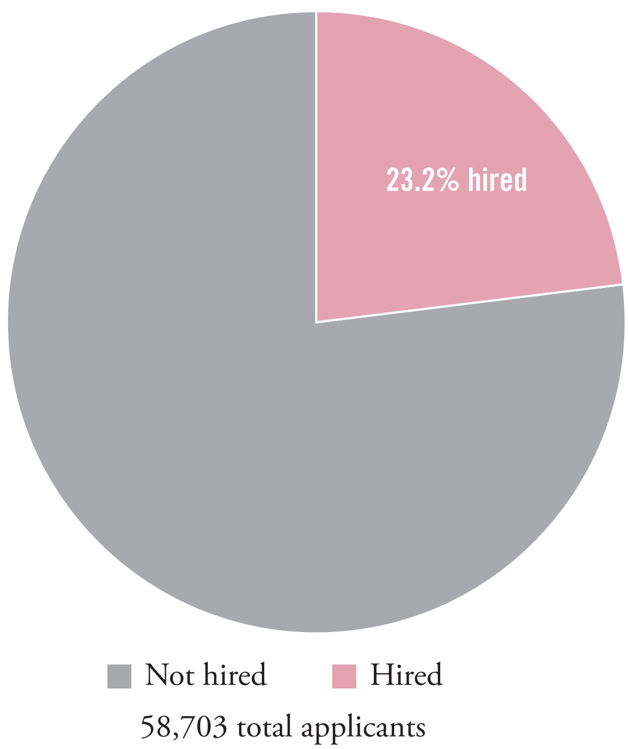
The Japanese employment exams are different than teacher certification exams because these candidates are already qualified as teachers through graduating from an initial teacher education program. It is therefore relatively easy to become a qualified teacher with no extra steps after receiving a degree. Many more people are licensed than will receive teaching jobs each year. In 2012-2013, there were about 28,300 newly certified elementary school teachers for about 13,600 public school positions.[214]

The employment exam system means that the most rigorous assessment of candidate skills is at the point of hiring, working to weed out candidates who may not be well prepared to teach. Each prefecture ranks candidates based on their employment exam score and only selects teachers from the top of the ranks.[215] This means there is no “passing” score that ensures a position – only top-achieving candidates will be offered a job. The competition for teaching jobs is high: in 2013, there were 4.3 candidates for every elementary school teaching job.[216]

The written examination includes a rigorous test of subject expertise in all subjects for elementary school teachers. It may also include sections on pedagogical theory and methods, educational psychology, and other related topics. Most prefectures also have a personal interview that often includes a demonstration lesson.[217]

This process sends a powerful signal not only to teacher candidates but also to initial teacher education providers: teacher subject expertise is assessed because it matters. Initial teacher education courses need to focus on developing deep subject expertise or their graduates will never get high scores in the employment exam. The impact varies greatly from a focus of minimum standards.

Figure 9 Aspiring Elementary Teachers in Japan – Examinees and Hired Teachers (2013)



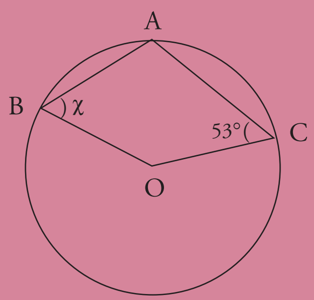
Source: Ministry of Education and Culture, Sports, Science and Technology – Japan, 2015

Box 6 Sample Math and Science Questions From an Elementary Teacher Employment Exam (Japan)

When the decimal part of $\sqrt{5}$ is χ, choose one from the next 1 to 4 as the right value for $\chi^2 + 4\chi + 4$

1. 5
2. 10
3. 16
4. 25

The quadrangle ABOC is created by marking 3 points A, B and C on the circumference of a circle centered at point O. When ∠BAC = ∠BOC, and ∠ACO = 53°, choose one of the 1 to 4 as the right degree of ∠ABO = χ



1. 47°
2. 57°
3. 67°
4. 77°

What factor determines if the weather is either clear, fair, or cloudy? Choose one from the next 1 to 4.

1. The type of cloud
2. The shape of cloud
3. The percentage of steam
4. The ratio of clouds in the sky

Select the correct order of A to D, which describe the characteristics of sodium hydroxide aqueous solution.

(A) A red litmus paper turns blue.
(B) Phenolphthalein solution turns red.
(C) BTB solution turns yellow.
(D) A blue litmus paper turns red.

1. ABC
2. BCD
3. AB
4. BD

Questions are from the 2015 elementary teacher employment exam in Saitama prefecture. Saitama Prefectural Board of Education, 2015a

More examples from the employment exams can be found in the appendix.

5 Specialization

In the United States, elementary school teachers are likely to be generalists, teaching all (or many) subjects. Because teachers need deep subject expertise to teach well, elementary school teachers have a unique problem – how can they develop expert knowledge in each of the many subjects they are teaching?

Specialization is one way to help teachers develop deep expertise, and all four high-performing systems studied have some aspect of specialization.

But specialization in these systems is much more nuanced than what usual debates on specialization would suggest; it is not just about whether or not you only teach 4th grade math in elementary school. It is more helpful to think about the *degree* of specialization in the range of elementary subjects taught and the degree of specialization in initial teacher education.

Thinking about the degree of specialization in teaching and in initial teacher education opens up more possibilities for reform. Systems with generalist elementary teachers can still help teachers develop specialist expertise without completely changing their job structure.

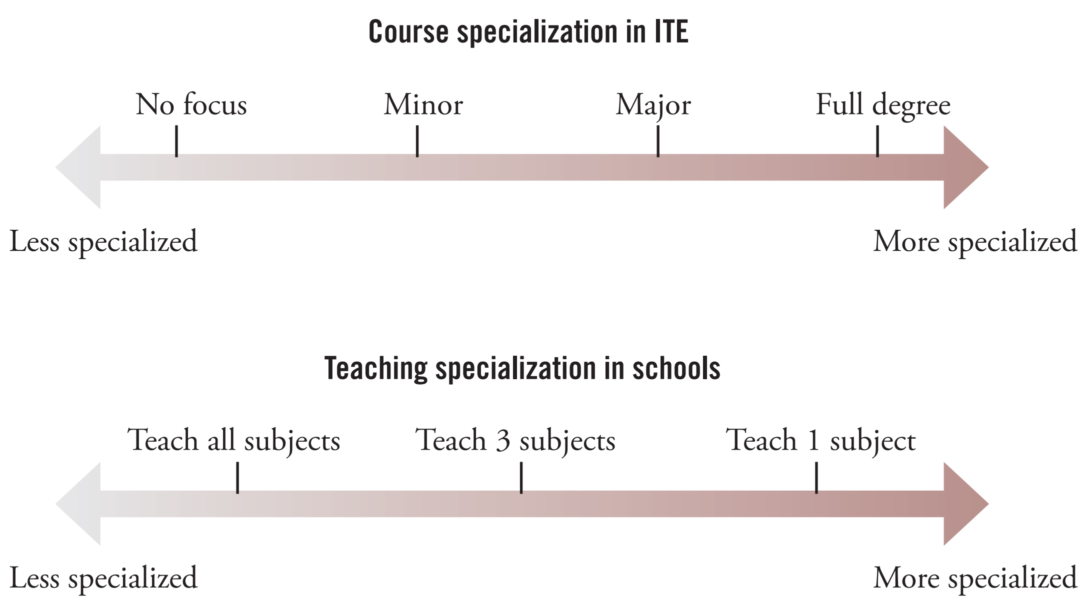
Specialization can manifest itself in various ways, which makes it difficult to classify systems clearly as "specialized" or "not." It is more useful to look at specialization on a spectrum within these two categories:

1. **In initial teacher education:** Do elementary teachers have more training in one or a few subjects rather than equal training in all subjects?
2. **In schools:** Do elementary teachers teach one or a few subjects instead of all subjects?[218]

While the four high-performing school systems each have a focus on teacher specialization at the elementary school level to some degree (in either initial teacher education or schools or both), this focus is reflected in the initial teacher education curricula in different ways for each of the systems.

Finland and Shanghai occupy opposite positions on the job specialization spectrum. Elementary school teachers in Finland generally teach many subjects, and teachers in Shanghai only teach one or a few subject(s). The examples below give an indication of how particular initial teacher education institutions within the systems structure their training programs to best prepare their teacher

Figure 10 Two Ways to Map Specialization



candidates for the particular demands they will face once in the classroom.

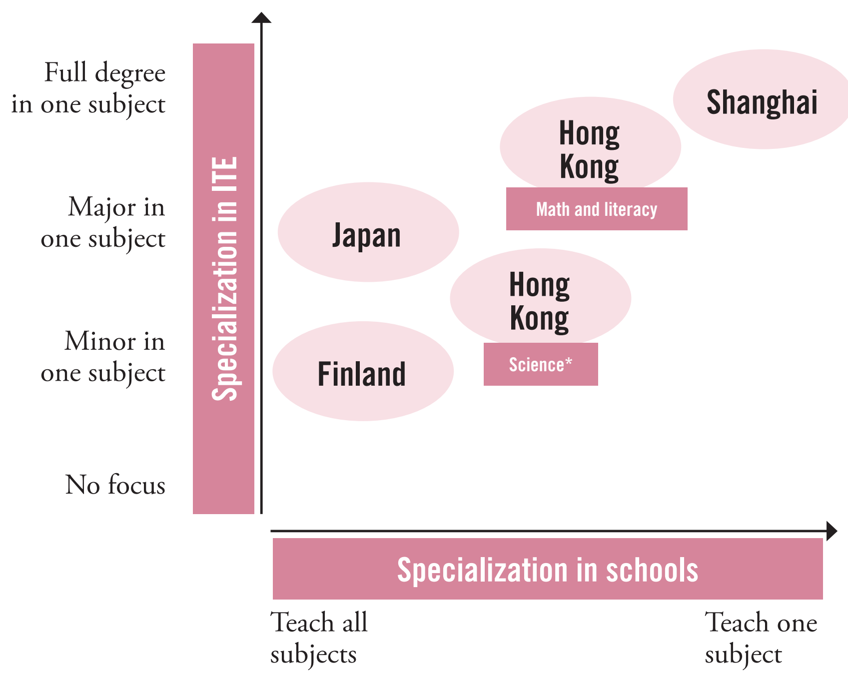
Japan and Finland are generalist systems, where elementary teachers teach most or all subjects.[219] In both countries, initial teacher education focuses on all subjects, but teachers choose a subject to major or minor in. Japanese teachers generally choose one subject specialization in initial teacher education, but Finnish teachers generally choose two. While teachers in these systems may not have deep subject expertise in every subject they teach upon exiting initial teacher education, these systems recognize that subject knowledge is not just developed in a teacher education program. There is an expectation that additional expertise will developed through ongoing in-school professional learning. And because each teacher has an area of deeper expertise, schools can ensure there is an expert in each subject on staff. (See the induction and professional learning chapters below for more information on how these systems develop teacher subject expertise in all subjects.)

Hong Kong and Shanghai elementary teachers specialize in both initial teacher education and in their teaching role. Shanghai is more strictly specialist than Hong Kong. In Hong Kong, science teachers actually teach a subject called General Studies, which includes science. General Studies includes three Key Learning Areas: science; personal, social, and humanities education; and technology education. General studies teachers' initial teacher education must cover each of these areas, so it is a more generalist role than Hong Kong teachers of language or mathematics. In addition, all Hong Kong teachers are likely to teach some subjects outside their specialty but are not full generalists like Finland and Japan.

5.1 In-school specialization may help decrease workload and improve subject expertise

Specialization of the teaching role is not the only way to improve teacher subject expertise. However, there are several potential benefits to in-school

Figure 11 Different Approaches to Specialization



Note: This is generally representative, but individual schools and initial teacher education programs within each system may have different models.
**In Hong Kong, science is included the subject called 'General Studies' which includes other subjects like social studies, but does not include math or literacy which are each specialized subjects.*

specialization where teachers only teach one or a few subjects:

- **Increased subject expertise:** With fewer subjects to teach, teachers can go deeper on the planning, preparation, and professional learning for their subject(s). This would allow them more time to develop their pedagogical content knowledge and give them more confidence in their teaching abilities.[220]
- **Decreased workload:** Teachers prepare for fewer subjects, which might require less work. This may lead to lower teacher burnout (and less stress) – particularly in the first few years of teaching.[221]
- **Teachers can focus on subjects they are most interested in:** This will vary depending on school need, but ideally teachers that have a passion for a particular subject can focus more on teaching in their interests.[222]
- **Increased collaboration:** Schools can structure specialist teaching roles to exist within a team of teachers who all teach the same students. This may increase teacher collaboration since they are able to discuss student learning with other teachers that also know the same students well.[223] If collaborative teacher professional learning is not well established in the school, however, the opposite could happen and result in decreased collaboration.

Enhancing student/teacher relationships may help alleviate concerns with specialization

One potential and important downside to in-school specialization is diminished student-teacher relationships. When teachers teach only 1-2 subjects, they have more students, and they do not know their students as well as generalist (i.e., self-contained) teachers.

A recent study of elementary teacher specialization in Houston found that specialization had negative effects on student outcomes, and that this may have been because teachers reported giving less attention to individual students.[224] This is in line with the arguments of opponents of specialization, who believe that it reduces focus on the whole child and instead puts too much emphasis on academic subjects.[225] There is evidence that teachers in a generalist role have stronger relationships with students as their primary teacher and that their students feel more connected to the school.[226] This is also true for parent/teacher relationships – which makes sense, since teacher specialization would mean teachers have more parents to build relationships with as they teach more classes across the same subject.[227]

One way to ease the concern about teacher/student/parent relationships is to combine teacher specialization with teacher "looping". Looping is a practice where teachers follow the same group of students for at least two school years, teaching them from one grade level to the next.[228] Looping has the benefit of improving relationships because

Box 7 Small Case Study in the United States Finds Benefits to Specialization in Schools

A 2014 study followed 12 generalist elementary school teachers who were asked by their school leaders to try specialized instruction for a year. Researchers compared the experience of these teachers with other teachers who continued as generalists in the same school.

The specialized teachers experienced higher morale, lighter workload, and increased overall job satisfaction in comparison to the generalist teachers. The teachers trying out specialized teaching overwhelmingly preferred the new structure to their old teaching roles.

Source: Strohl, Schmertzing, Schmertzing, & Hsiao, 2014 teachers see the same students for multiple years.[229] Looping can also address some of the whole-child concerns with specialization: looping reduces student anxiety, helps build student social skills, and improves student confidence.[230] It is common for teachers in Finland, Shanghai, and Japan to "loop" with their students: to follow the same group of students up to the next grade level for at least two or three years in a row, and sometimes throughout every elementary school grade level.

"Loopers" may actually have enhanced subject expertise because teachers are more familiar with the full conceptual picture of how student knowledge in one grade leads to learning in the next.[231] While some evidence suggests that random grade switching makes teachers less effective, loopers are typically assumed to not have many of the issues that typical grade-switchers might have.[232] This is partially because of the benefits of increasing teacher knowledge of the individual students over time, as well as the fact that moving one grade level up is not as difficult as larger grade or subject level changes.

Another dimension of specialization is grade level

Specialization is often thought of as subject-specific, but it makes sense that the knowledge a teacher gains from being specialized would also be bounded by grade level.

There is recognition of this issue in Hong Kong, where cross-sectoral programs that allow teachers to be certified for both elementary and secondary instruction are becoming more popular. These programs have benefits including attracting stronger candidates (because the degree allows for more career options) as well as increasing the workforce flexibility for changing system needs.

However, there is concern that the subject expertise required for elementary versus secondary teaching is too different and therefore graduates of these programs may not be as well prepared. In response, Hong Kong's Education Bureau has recommended that certain subjects are not preferred for cross-sectoral programs, including math and science.[233]

5.2 Generalist teachers can have specialized training and development

Many schools do not want to change from a generalist model of elementary school teaching, but these schools can still benefit from teachers having specialized knowledge.

In Japan, elementary school teachers teach all subjects, sometimes including physical education, music and art. This is different from systems in many other countries where there is usually a specialized teacher for these additional subjects. In many cases in Japan, teachers will even have to take an exam in music ability or physical fitness before they are hired to show that they can teach all subjects well.

Finnish elementary school teachers generally teach all subjects. In both Japan and Finland, there is some flexibility in how this is structured. Schools can make different decisions based on need; for example, large schools may decide to have some teachers focus on only one or a few subjects. But the majority of elementary teachers in both countries have generalized teaching responsibilities throughout their careers.

Even so, teachers in both of these countries are likely to partially specialize during their training in initial teacher education. In Japan, prospective elementary school teachers often choose a major, which allows them to take extra subject expertise courses in one subject. In Finland, it is common for teachers to minor in one or two subjects.

5.2.1 Generalist teachers with specialized knowledge can become subject leaders in schools

The benefit of having specialized knowledge from initial teacher education is that schools can hire teachers to ensure that there is expertise in each subject at the school. A teacher who trained more deeply in math can lead the math planning team and help other teachers with less math subject expertise.

An example of how this works comes from the Saitama prefecture in Japan. The prefecture selected an elementary school teacher to take part in one year of specialist training (she was the only teacher selected for the entire prefecture). The science program was selected because the prefecture noticed declining interest in science from students combined with the fact that not many teachers had a strong background in science. The teacher then offered demonstration lessons, feedback, and advice to other teachers in the prefecture.[234]

Saitama also developed a "core" science teacher system to further develop teacher science knowledge in each municipality. Each municipality recommended a teacher to be trained at the prefecture and then the teachers were sent back to their local areas to help other elementary school teachers. The training focused on subject expertise, including specific teaching methods, like conducting experiments in science.

6 Foundational Content Preparation in Initial Teacher Education

Initial teacher education is where most teaching candidates begin to develop knowledge specific to teaching. In systems like the United States, where some teachers' own elementary and secondary school education may be lacking, initial teacher education can be an intervention opportunity to improve candidates' subject expertise before they become teachers in schools.

Elementary initial teacher preparation programs in the high-performing systems analyzed in this report had three things in common:

- Focus on foundational knowledge that teachers need at the elementary school level
- Emphasis on pedagogical content knowledge and not just general pedagogical skills
- High degree of alignment to national school curriculum

The initial teacher education programs focus on the development of subject expertise, but this doesn't mean that elementary school teachers in these countries all have master's degrees or PhDs in their subjects. The systems understand that it is more important for elementary teachers to develop a deep and flexible understanding of foundational content taught in elementary school level rather than advanced content. Advanced content can be helpful, and it is incorporated in many programs, but it is not the main focus of elementary preparation programs.

To achieve this, subject expertise is developed across initial teacher education programs. It is not separated into one or two courses focusing on specific areas of content such as a single course on elementary school mathematics that is typical

Box 8 An Example of How Generalist Schools Can Use Specialist Knowledge

Sako Primary School (Tokushima, Japan)

At Sako Primary School (Tokushima, Japan), a Curriculum Coordinator acts as the main expert teacher for each subject. The 2015 science coordinator has 31 years of teaching experience and organizes the monthly science curriculum plan for the whole school. Part of his role also involves mentoring novice teachers. During summer vacation, he taught two new teachers how to use teaching materials in the subject.

The principal appointed this coordinator because of his experience and expertise. It is his first time in the Curriculum Coordinator role, and the role may only last for one year – after which he may go back to full-time teaching. The principal believes that appointing teachers to positions like these are some of the most important decisions he makes each year. The role of Curriculum Coordinator and other senior teaching roles are not paid significantly higher than other teaching roles, but the role carries prestige.

Source: Interview with Sako Primary School – November, 2015 in the United States. In addition, initial teacher education programs in these systems focus on subject expertise not only in courses, but also in practicums and other program experiences (e.g., studying abroad).

In the United States and a number of other systems around the world, debate around developing subject expertise in elementary teachers has focused exclusively on content knowledge, or a lack of it, and rarely on pedagogy connected to that content. In high performing countries, there is recognition of the importance of subject specific pedagogy and this is a key element in their training of elementary teachers.

Another important element of the teacher preparation curriculum in these systems is its connection to a national elementary school curriculum. In all four systems, there is a national elementary school curriculum (although there is some ability for districts and schools to adapt curriculum to the local environment). To varying degrees, initial teacher education institutions have based their curriculum for teacher education on the content knowledge and pedagogical content knowledge that elementary teachers will most need in the classroom to teach the elementary curriculum. It is common for curriculum updates to occur on a regular basis (e.g., every 10 years in Japan) and for the central authorities to consult heavily with initial teacher education providers during the revision process so that teacher education reflects the most up to date curriculum.

Quality is more important than quantity

While this report emphasizes the development of subject expertise in teachers, this does not imply that systems should just increase the quantity of subject expertise courses in initial teacher education or regulate which courses teachers should be required to take.

The fact that a teacher goes through a course actually says little about the amount a teacher has learned in that course, and courses likely vary significantly in quality. This might explain why there is no clear correlation between the number or type of courses a teacher takes and his or her performance in a classroom.[235]

It is therefore more important for systems not to overemphasize inputs and instead focus primarily on outputs: the level of subject expertise teachers gain and its eventual impact on student achievement. This requires, among other things, a focus on strong evaluation of changes to initial teacher education programs and policies in order to build the evidence base for how best to develop subject and pedagogical expertise in teachers.

Research on quality of teacher preparation is limited

Because of a poor evidence base on "what works" in initial teacher education, policymakers need to emphasize the creation and effective use of evaluative data on new programs and policies in order to build the evidence base. Current issues with research include:

- **Little consistency on how to measure teacher knowledge.** Many studies use proxy measures to assess teacher knowledge, like number of courses taken. Direct measures, like exams, are less common but much more useful.[236] Only in recent years have researchers tried to develop more direct tests of relevant subject matter knowledge in preservice and in-service teachers, and much of this has focused on mathematics.[237]

- **Initial teacher education providers do not collect much data on their candidates.** Very few initial teacher education programs assess teacher subject expertise on entrance to programs or at graduation. Few initial teacher education providers make any attempt to document teachers' existing level of knowledge in a bid to design subject matter coursework more effectively.

- **Difficult to isolate the effects of one course/ program.** If teachers grow in knowledge, it is often hard to attribute the growth to one factor when many things could be causing the impact.

- **Few longitudinal studies from initial teacher education to schools**. Very few studies follow preservice teachers as they move into teaching positions, so while the studies may measure improvements in teacher knowledge, they cannot say how this affects teaching and student learning.[238]

6.1 Specialization in initial teacher education can help develop deeper knowledge

Initial teacher education is time-constrained: programs only have time for a certain number of courses and learning programs. Therefore, it can be difficult for programs to create enough opportunities for elementary school teachers to develop subject expertise in the many subjects they often teach. Systems can partially address this issue by allowing elementary school teachers to specialize during initial teacher education. They can either fully specialize and prepare to teach just one subject (e.g., just literacy), or they can partially specialize by choosing one to two subjects for a major or minor while still preparing for a generalist role.

There are two types of initial teacher education design for elementary teachers in the systems studied: one for teachers who will be generalists (Finland and Japan), and the other for teachers who will be specialists (Shanghai and Hong Kong). In the specialist initial teacher education programs, there is more time for courses in content knowledge, because prospective teachers are taking most courses in just one subject. For example, a student teacher in Hong Kong who wants be a specialist elementary math teacher can focus her initial teacher education around building deep math expertise. Teachers in generalist programs take courses in all subjects, so they necessarily spend less time on each subject.

However, the generalist systems analyzed in this report (Japan and Finland) have teachers choose one to two subjects for a partial specialization. Even though they still have to prepare to teach all subjects, they take the equivalent of a major or minor in a subject of their choice. This means that they have the opportunity to go deeper in content knowledge and pedagogical content knowledge for that subject, developing subject expertise.

6.2 Specialist systems: Hong Kong and Shanghai

In Hong Kong and Shanghai, teachers often choose a subject-specific program for the subject they want to teach in elementary school. The programs have a relatively large focus on the content knowledge in the course load, because teachers are mainly taking courses in just one or two subjects. Pedagogical content knowledge is also an important component of these programs.

6.2.1 Hong Kong

Elementary school teachers in Hong Kong are mostly specialists in one subject (e.g., a math teacher only teaches math). However, there is a "general studies" subject that covers multiple areas: science; technology; and personal, social and humanities (similar to social studies). So, science teachers actually have a more generalist role in teaching than other teachers as they teach all three general studies subjects.

For both literacy and math teachers, initial teacher education programs can have a larger focus on content knowledge because teachers only focus on one subject. Critically, they are also focused specifically on content at the elementary school level.

Example initial teacher education provider: Hong Kong Institute of Education (HKIEd)

About 25 percent of the course content in a five-year elementary school math major program at HKIEd focuses on math content knowledge. The students in the program are considered to have majored in math for elementary school.

Prospective general studies teachers still take about 25 percent of courses in their major. These courses are split between the three subjects within general studies. With the more limited course time, the program cannot go as deep into the content knowledge for science as the courses for math or literacy teachers.

Box 9 Required Courses for Five-Year Elementary School Math Major Program at Hong Kong Institute of Education (HKIEd)

Required courses for math major:

- Geometry and measurement
- Understanding numbers (overview of basic number concepts in elementary school math)
- Elementary number theory (e.g., properties of integers)
- Problem-solving
- Recreational mathematics (activity approach of learning/teaching math)
- Essential mathematical concepts (e.g., logical reasoning and rigorous mathematical language)
- Development of mathematical ideas (overview of origin of important mathematical ideas)
- Mathematical exploration with technology
- Probability

Elective courses (must choose one from each pair):

- A) Introduction to analysis or B) Calculus
- A) Statistics or B) Statistical modeling
- A) Vectors and geometry or B) Linear algebra
- A) Modern algebra or B) Plane geometry

Two required pedagogical content knowledge courses:

- Learning, teaching and assessment in elementary mathematics
- Curriculum and teaching of selected topics in elementary mathematics

Curriculum outline available in appendix
Source: Hong Kong Institute of Education, 2015c

Because of this, programs may choose to focus less on content knowledge and more on pedagogical content knowledge. For example, the general studies major at HKIEd includes the following core courses related to science (but may also include elements of other general studies subjects):

- Environmental science
- Healthy living
- Children's science learning
- Natural world
- Science, technology, and society

The science taught to teachers in the general studies major at HKIEd is highly related to the elementary school curriculum. It is therefore focused on science related to daily life instead of typical hard sciences. The courses aim to give teachers strategies to incorporate science into daily topics. The curriculum also has an emphasis on interdisciplinary learning that is a goal of the general studies curriculum.

Students taking the general studies major at HKIEd are usually from an arts background (not science). Some of these prospective teachers might share the same issues of elementary teachers in the United States around science: it is hard to get them to become interested in science, and they may avoid teaching science once in schools.[239]

To generate interest in science and model teaching strategies, the general studies courses are taught with an inquiry approach where teachers design activities for class that have a science component. Initial teacher education uses a hands-on approach with discussion and simulation.

6.2.2 Shanghai

Shanghai also prepares teachers to be specialists, so initial teacher education courses have a relatively large focus on content knowledge. During a four-year bachelor's program, up to 20-25 percent of courses build subject expertise in the specialization area of choice. As in the other systems, the subject expertise courses are focused on knowledge at the elementary school level. However, because teachers are being prepared for specialist roles, there is time to include advanced concepts in the program as well. For elementary school teachers, most courses for subject expertise are housed in the education department, which means the courses are designed specifically for teachers (and not a general audience).

Whereas many systems worry about the math competency of elementary school teachers, Shanghai has particular pride in the preparation and development of math teachers. Initial teacher education programs are designed to ensure math teachers are experts in the subject. An elementary math education professor at Shanghai Normal University described the importance of mathematics training for teachers: "In China, the mathematics teacher is like a mathematician."[240]

Shanghai shares some commonalities with Finland in that all of its prospective elementary school teachers must complete a research thesis. This, in conjunction with a collaborative practicum experience, prepares teachers with a research mindset that they will use to continually develop subject expertise after initial teacher education.

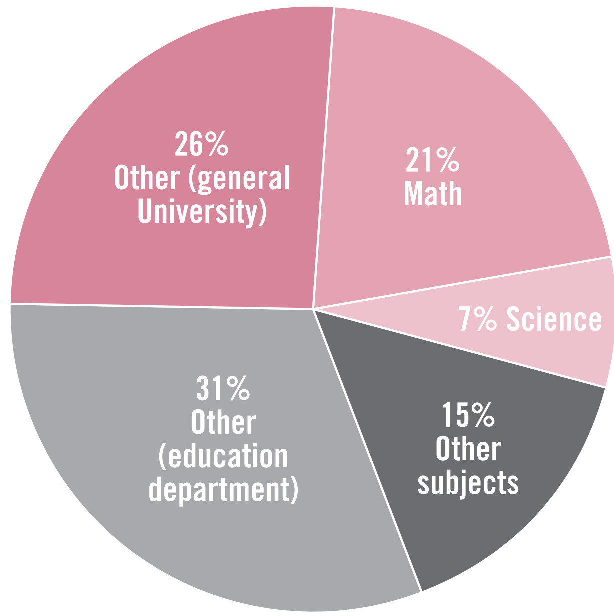
Example initial teacher education provider: Shanghai Normal University

Shanghai Normal is a large university that has prepared about 70 percent of elementary school teachers in Shanghai. Prospective elementary school teachers can choose one of three specific discipline strands: "language-social sciences, math-natural sciences, and performance or fine arts and crafts."[241]

Aspiring elementary school math teachers take the math-science strand and therefore have a few science courses in addition to a majority of math courses. Math teachers also take a few courses in other subjects taught in elementary school, such as Chinese character writing and basic music theory.

Student teachers take courses at the foundational elementary school level (e.g., early elementary number theory), but they also take courses in advanced math topics (e.g., calculus). Almost all math courses are taught by faculty in the education department.

Figure 12 Shanghai Elementary Math Teacher Required Course Distribution



Source: Shanghai Normal University curriculum[242]

Figure 13 Math Subject Expertise Courses at Shanghai Normal University

Foundational content in bold.

Year	Math courses taken
1	• Advanced mathematics • Calculus • **Early elementary number theory**
2	• **Real numbers** • Linear algebra and analytical geometry
3	• **Probability** • **Mathematical thinking and methods** • **Mathematical culture** • **Primary math curriculum and teaching** • **Clinical case studies of primary math teaching**
4	• Thesis

Source: Shanghai Normal University curriculum

Prospective math teachers are also likely to take the following math electives in the second and third years:

- Elementary mathematics research
- Discrete mathematics
- Combinatorial mathematics
- Elementary math Olympiad counseling
- Probability and statistics

6.3 Generalist systems: Finland and Japan

Finnish and Japanese elementary teachers teach all subjects, so they must therefore study all subjects during initial teacher education. In general, this means programs have a few required courses in each subject that touch on the basics of content knowledge and pedagogical content knowledge but cannot go into too much depth because there is limited course time. The few required courses for each subject are usually focused directly on the foundational matter covered in elementary school teaching.

Pedagogical content knowledge is a big focus of generalist initial teacher education courses in Finland and Japan, even though it is not always referred to as pedagogical content knowledge. The courses teach a range of pedagogical strategies to effectively support student learning, including how to recognize and correct common student misunderstandings and how to differentiate their instruction to ensure learning across the broad range of abilities teachers are likely to encounter in their classrooms.

In addition to taking courses for a generalist subject expertise curriculum, teachers in Finland and Japan also choose a major and/or minor subject in which to specialize. The subject they choose becomes their area of specialization in which they develop deep subject expertise. In so doing, they understand what is required to develop deep expertise in a given subject, and they build the skills required for developing deep expertise. This means that they develop strong research skills, they deeply understand student assessment in their subject area, and they develop the skills to evaluate the impact of their own practice on students.

These skills set them up for a career where they can further develop subject expertise across all subjects they teach. So even though they specialize in only one subject in initial teacher education, they develop the research, evaluative and inquiry skills that are fundamental to effective professional learning once they are in schools. The skills they learn in their specialized subject in initial teacher education enables them to develop deep expertise across all subjects over the course of their career.

Teachers can also utilize their specialized subject expertise for school improvement. After some teaching experience, they may become the expert in their school for their chosen subject; being able to lead curriculum discussions and mentor teachers with less subject expertise.

6.3.1 Finnish elementary teacher education

Each teacher in Finland is required to have both a bachelor's and master's degree, and initial teacher education programs comprise at least five years of study that include both degrees. Elementary school student teachers only have a few required courses in each subject throughout the five years they study. This is a tiny amount of time to try to pack in subject expertise, so the courses do not focus directly on content knowledge and instead are designed to teach pedagogical content knowledge basics. There are instead two ways that Finnish elementary teachers are expected to get their content knowledge:

1. **Strong secondary school preparation:** The bar is set high for entry into initial teacher education, and the quality of secondary education in general is excellent in Finland. So, professors often assume that incoming student teachers are well prepared with the content knowledge needed to teach elementary school.

"They have been studying it for 12 years already, and if they don't know it, I can't change it in this small amount of time"

– Academic staff member, University of Jyväskylä

However, Finnish student teachers do not come in with perfect content knowledge. They actually have some of the same issues as teachers in the United States, including generally being stronger in literacy skills than in math or science.

For example, professors at the University of Jyväskylä explain that matriculating student teachers have at least some math difficulties and only 5 percent have previously taken more than one course in science. [243]

2. **Self-study of content knowledge gaps:** While there may not be time to instruct directly on content knowledge in initial teacher education courses, professors trust student teachers to construct any lacking knowledge on their own. Professors supervise student teacher progress and monitor the depth and level of their content knowledge. If any gaps are identified, then students are given suggestions of further readings.

For example, a literacy professor at the University of Helsinki notes that she does not explicitly teach her students parts of speech (e.g., nouns, verbs, adjectives) because she expects them to already have background knowledge. When students do have knowledge gaps on the topic, she gives them a book explaining parts of speech that they can self-study.[244]

Finland is known for requiring all teachers to complete a master's degree with a thesis. Part of the rationale for this is to help teachers develop research skills so that they can employ them once in schools to help develop their knowledge and practice. Therefore, part of the curriculum in Finnish initial teacher education is training in research methods. This training not only helps with teaching research skills but also builds knowledge in math and science topics related to research skills (e.g., statistical analysis).

Box 10 Subjects Taught by Finnish Elementary School Teachers

As generalists, Finnish teachers must prepare to teach many subjects. Student teachers at the University of Jyväskylä take two courses in each of the following subjects:

- Finnish language and literature
- History and social studies
- Religion and ethics
- Art
- Physical and health education
- Mathematics
- Music
- Technology education and technical handicraft
- Handicraft education and textile handicraft
- Environmental and natural science

As part of the generalist initial teacher education curriculum, elementary teacher candidates take a few subject expertise courses in each of the many subjects they teach. These courses are mostly focused on pedagogical content knowledge and cover topics specific to elementary school teaching. Because of the many subjects that must be covered, there are usually just two to three courses for each subject (see University of Jyväskylä example below for more detailed information about the courses).

Finnish initial teacher education for elementary teachers tends to be fairly practical, but its practicality does not mean teacher candidates aren't expected to learn theory. Many courses are structured to require relatively heavy out-of-class reading.

Box 11 Finnish Student Teacher's Experience Studying in the United States

Some Finnish teachers have had a unique opportunity to directly experience both United States and Finnish initial teacher education and compare the two. At the University of Jyväskylä, some student teachers participating in a special English-language initial teacher education program have studied abroad in the United States.

One student teacher explained that one of the biggest differences between Finland and the United States was that Finnish initial teacher education felt a lot more practical but also required much more reading of academic texts. She explained that she didn't feel like her Finnish teacher education was more challenging per se, but that the work required in the United States felt less relevant.

Source: Interview at the University of Jyväskylä – November, 2015

How Finnish teachers specialize in initial teacher education

In addition to taking a few subject expertise courses in each subject, teacher candidates also choose minors in which they can develop specialized knowledge. These minors can represent up to 20 percent of the total initial teacher education curriculum, so there is significant opportunity for teachers to develop deep knowledge in an area of choice.

Depending on the subject, the courses for a minor may exist inside the department of teacher education or in another faculty at the university. For example, teacher candidates may choose to minor in subjects such as special education, physical education, music education, or early childhood education (among others) – all of which are in the department of teacher education.

However, if a teacher chooses to minor in a science or math subject, she will likely take courses in the science or mathematics departments. The courses for minors in other programs are for all university students, so they do not address knowledge specific to teaching and therefore work to develop general content knowledge. The popularity of these types of minors may differ depending on the university. For the University of Jyväskylä, it is fairly rare for teachers to choose minors in these subjects.[245] At the University of Helsinki, mathematics, history, and geography are popular minors in other faculties.[246]

It is becoming more popular for elementary student teachers to choose to do dual-degrees, where they take enough subject expertise courses to qualify to teach secondary as well as elementary school.[247] This would mean effectively taking the equivalent of a major of subject expertise courses in a chosen subject (e.g., physics) in addition to the courses that make up the generalist core of subject expertise courses.

Example initial teacher education curriculum: University of Jyväskylä

At the University of Jyväskylä, preservice teachers take two mandatory courses in each teaching subject – a basic course and an applied course. As mentioned above, there is limited content knowledge taught in these classes. Instead, they focus on teaching pedagogical content knowledge basics. Even though the focus is on pedagogical content knowledge, some content knowledge is taught through the examples discussed in class.

Example: basic math course

The basic course involves four lectures and 10 small group sessions (90 minutes each). It includes general teaching topics related to all math subjects, as well as the specific subjects of geometry, calculation with large numbers, fractions, and pre-algebra. General topics include:

- Using manipulatives
- Introducing a number system as an unfamiliar topic to students
- Fears of and feelings about math
- Hypothetical situations from the classroom
- Computer software to use for math instruction
- Inquiry-based math

The lectures tend to consider these topics from a more theoretical standpoint than the seminars do, though each has a strong focus on developing pedagogy.

The applied course focuses more on practice than theory and takes a number of novel interdisciplinary approaches, such as teaching mathematics through inquiry-based design and combining math with computers or art.

6.3.2 Japan's elementary initial teacher education curriculum

In Japan, the Ministry of Education sets a minimum number of content and pedagogy courses initial teacher education candidates are required to take. However, many universities design programs that include far more subject expertise courses than the minimum required. Initial teacher education providers might have an incentive to make sure elementary teachers graduate with enough subject expertise because they want to make sure they can pass the employment exam and get a good teaching position.

For example, Tokyo Gakugei University, a prominent teacher education university in Tokyo, emphasizes subject expertise requiring more than three times the amount of subject courses than the minimum set by the Ministry of Education.[248] At Tokyo Gakugei University, prospective teachers take two courses for each subject and there are nine subjects. Professors at Tokyo Gakugei University acknowledge that the courses give only a small glimpse of pedagogical content knowledge, while most pedagogical content knowledge is developed in lesson study once teachers are in schools.

Japan is known for developing teachers through lesson study, which refers to in-school professional learning that is subject-specific and improves pedagogical content knowledge (see professional learning section for more information on lesson study). But lesson study is introduced in initial teacher education and is a key feature of teacher candidates' development, particularly during the practicum (see below for more information).

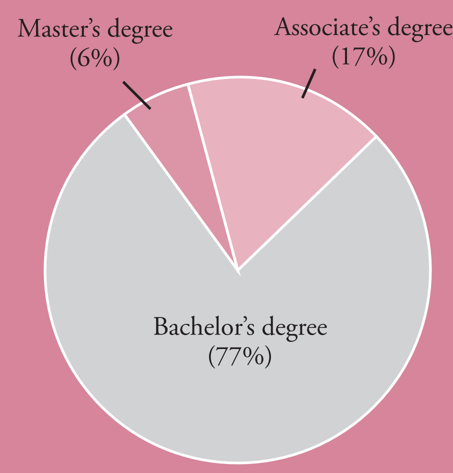
Like initial teacher education in Finland, Japanese elementary initial teacher education programs prepare teachers for all subjects but still have specialization in one or a few subjects. [245] This is true at Tokyo Gakugei University, where teachers may specialize in subjects like math or science.

Box 12 Few Teachers Have Master's Degrees in Japan

In Japan, completing an initial teacher education program is the only requirement for becoming a certified teacher. Most elementary teachers are certified after completing a four-year bachelor's program and few complete a master's. This is in contrast to Finland, where all teachers are required to have a master's. In Japan, there is no incentive to obtain a master's degree: teachers with one are not more likely to be promoted or paid more.

Prefectural boards of education sometimes select veteran teachers to complete an advanced certification, but few teachers are chosen each year and the process is usually very competitive.

Proportion of elementary school teachers with each degree type.



Note: Teachers with an Associate's degree are expected to eventually complete a Bachelor's degree.

Source: Ministry of Education, Culture, Sports, Science and Technology – Japan, 2015

Example initial teacher education curriculum: Naruto University of Education

Naruto University of Education in Tokushima prefecture is a relatively small teacher education university that recently redesigned its initial teacher education curriculum.

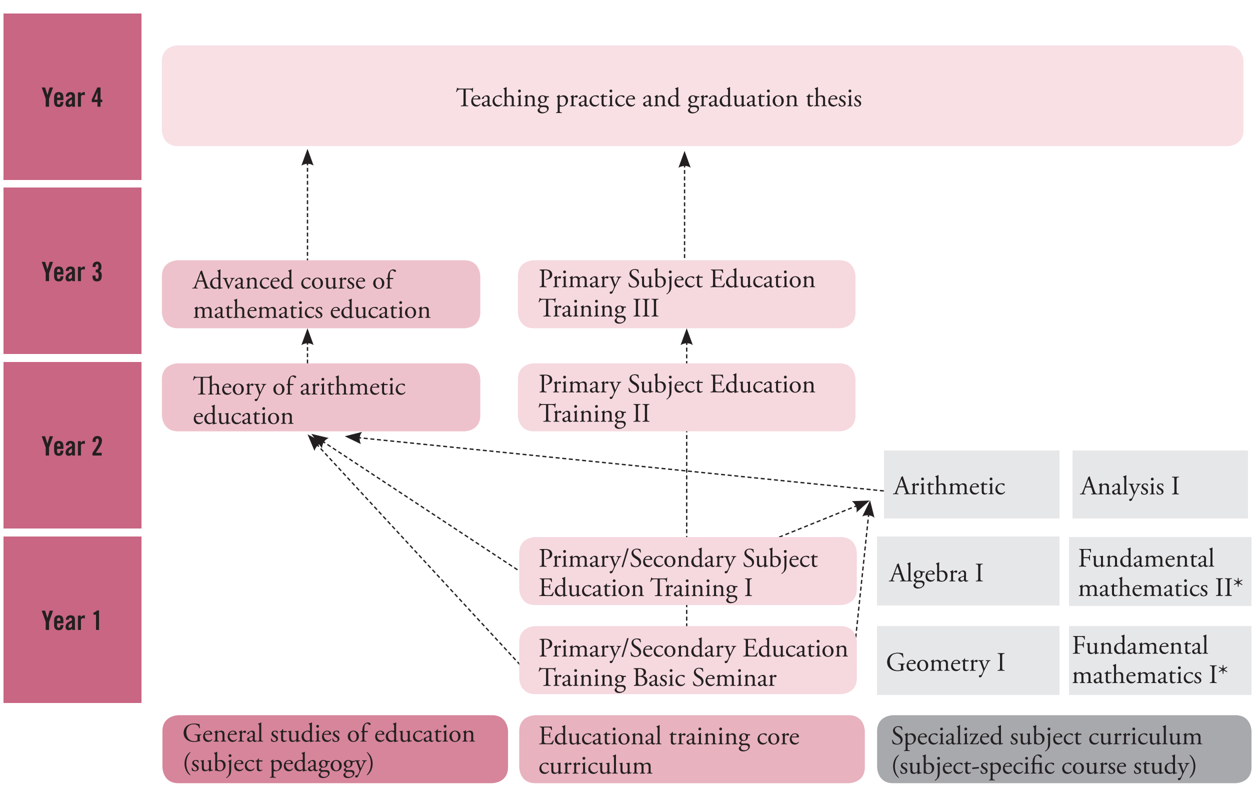
The curriculum now includes "core" courses for each subject that all prospective teachers take. Both prospective elementary and lower secondary teachers take these core classes together. These courses were developed by three types of teacher educators: a subject expert, a pedagogy expert, and a veteran teacher. The three work together to make sure the courses emphasize pedagogical content knowledge and the combination of theory and practice.[250]

Teacher candidates take three core courses in each subject, and there are ten subjects: Japanese, English, society, mathematics, science, music, arts, physical education, technology, and home economics. These three core courses cover the basics of the subject, but student teachers also choose one subject in which to specialize.

For example, the core math courses (which everyone takes) explain basics of teaching math in elementary and lower secondary school. The courses include instruction on:

- The mathematics school curriculum (referencing the Ministry of Education's Course of Study)
- How young children learn math
- Teaching methods for mathematics
- Overview of key content taught in early years, upper elementary, and lower secondary
- Practice creating lesson plans and micro teaching

Figure 14 Naruto University of Education (Japan) Elementary Mathematics Major Course Requirements



Note: The arrows show course prerequisites.
**Fundamental mathematics I and II are "electives," but in practice almost all elementary mathematics majors will complete them.*
See appendix for information on the literacy and science curriculum at Naruto University of Education.

If a teacher candidate decides to specialize in math, she takes the equivalent of a major in mathematics. The math major was designed to have a foundation in arithmetic, but includes courses in more advanced mathematics as well. There are two "fundamental mathematics" courses that are not required, but they are recommended to students who do not have a strong math background from high school. In practice, almost all elementary mathematics majors take these two classes.

The math major includes courses focused on both content knowledge and pedagogical content knowledge. The content knowledge courses include:

- Arithmetic I
- Geometry I
- Algebra I
- Fundamental Mathematics I (mathematics learned in high school; e.g., quadratic functions)
- Fundamental Mathematics II (bridging high school math to university level math; e.g., derivatives and integration)
- Analysis I (advanced calculus subsequent to fundamental mathematics courses)

Geometry, algebra, and analysis have subsequent elective sections that are more advanced.

Math majors also take pedagogical content knowledge courses that instruct on teaching methods for each key area of elementary mathematics, show basics of elementary mathematics assessment, and include the creation of lesson plans and a simulated practice lesson.

6.3.3 Practicums include strong subject expertise focus

Practicums can be a time to further develop pedagogical content knowledge as teacher candidates are exposed to student thinking and learning. However, in many systems, practicums are focused mostly on general pedagogy instead of subject-specific skills. Additionally, many student teachers are placed in host schools that have little capacity to provide a mentor teacher with deep subject expertise.[251]

The teacher training schools in Finland (the school attached to the initial teacher education provider) gradually give students control of the classroom

Box 13 Lesson Study in Japanese Practicum and Gaining Subject Expertise

At Tokyo Gakugei University, student teachers have short practicums where they are introduced to the lesson study process. The process helps teachers practice anticipation of student thinking in the subject, which is a key part of pedagogical content knowledge. The process is also very collaborative so that novice teachers do not have to rely on their own subject expertise to design the lesson, but can call on subject experts for feedback and advice.

Example of lesson study during practicum

Prior to a second grade math class, a group of student teachers work together to anticipate student thinking for a geometry lesson. One student teacher is charged with instruction, but during the class, the other student teachers and a math subject expert observe and take notes.

At the end of the class, they all convene for a discussion of how well they anticipated student responses, which helps them improve their pedagogical content knowledge. They now know more about student thinking in regards to this geometry topic, and they have new ideas about how to best present the material in class. They will write a short reflection on the class as part of their assessment for the practicum.

Tokyo Gakugei University, November 2015 during the practicum and tend to focus on subject expertise during the later stages. First, student teachers observe lessons and have discussions. Then, they focus on lesson planning. Lastly, they focus on subject expertise, particularly in teaching the subject in which they have chosen to specialize. Student teachers also begin to get very familiar with classroom textbooks during practicums, as Finnish teachers tend to rely heavily on these instructional materials (which help with gaps in subject expertise), especially during their first few years of teaching (see more in the chapter on instructional materials).[252]

In Japan, practicums are very short, sometimes only three to four weeks.[253] However, initial teacher education programs use the practicum to introduce teachers to lesson study, which is how Japanese teachers develop subject expertise in schools. Since initial teacher education can never fully prepare teachers with all of the subject expertise they need, it is important for teachers to understand the process of how to continuously gain subject expertise once they are in their teaching jobs. This is the purpose of lesson study, and this is why teacher education providers construct the practicum to introduce this practice to student teachers.

6.4 System leaders can work to build the capacity of initial teacher education providers

Without reforms to influence the content, quality, and practices of initial teacher education providers, policymakers have little ability to shape the incoming pool of teachers. Building the capacity of initial teacher education providers is difficult. The initial teacher education environment in many systems is often complex, and many providers are highly autonomous.[254] Some high-performing systems are overcoming these complexities in three key ways:

1. Evaluation;
2. Strategic funding; and
3. Relationships and dialog.

With these policy reforms, some initial teacher education providers in these systems have also found ways to build their own capacity.

Evaluation

High-quality evaluation is an important part of building capacity and improving performance in all sectors, including initial teacher education programs. Government focus on the evaluation of initial teacher education internationally is growing and is reflected in national and sub-national level policies, such as the new regulations for mandatory reporting on initial teacher education in the United States (e.g., initial teacher education providers must report their admission criteria).[255] This rising focus is a response to increasing global competition[256] and a desire on the part of initial teacher education providers and institutions to comply with the evolving norms of the teaching profession.[257]

In many countries, the need to improve initial teacher education is considered urgent. This urgency reflects the high stakes: the consequences of ineffective policy and structures to improve initial teacher education flow directly into the classroom, especially if there are not sufficiently strong assessments of teacher expertise throughout the teacher education pathway.

High-quality evaluative processes require adherence to the key features of evaluation generally, and the implementation of meaningful consequences that truly influence providers and support teacher development. A number of systems have committed to investing in evaluative measures with consequences. Some of the most common consequences of evaluation include

- creating and following a plan for improvement,
- implications for funding and/or administrative support,
- implications for reaccreditation; and
- publicized evaluation results.

Funding

Funding reforms can create incentives for initial teacher education providers to build their capacity in specific areas. Initial teacher education receives significant public funding in most systems, allowing increases or decreases in funding to be tied to the quality of programs or to targeted areas of strategic development.[258] System leaders can directly fund the development of better courses or improved practical experiences based on evidence, or fund research into effective initial teacher education when little evidence exists. High-performing systems including Hong Kong and Finland provide examples of targeted funding reforms to build initial teacher education capacity. For example, Finland's Ministry of Education and Culture provides strategic funding to initial teacher education providers to build capacity in specific areas, and Hong Kong established the Quality Education Fund to support improvements to education across a wide range of priority areas (see more details below).

Relationships and dialog

The effectiveness of policy reforms can be increased with productive relationships and regular, meaningful dialogue between governments and initial teacher education providers. These relationships can be direct and individual – where government representatives meet with individual initial teacher education providers, or they can involve government facilitating group dialogue between a number of providers. Initial teacher education providers may be able to learn the most from other programs that are already successful at producing strong beginning teachers, so system leaders can facilitate partnerships to share knowledge.

The group dialogue approach can be very cost effective, as it relies on sharing existing resources to improve initial teacher education programs. Both approaches have the benefit of building the capacity of initial teacher education providers without having to rely on heavy-handed regulation. In contexts where there is competition between initial teacher education providers, the group dialogue approach may not be as successful, so it may make sense to partner providers that are in different regions or serve difference groups of teacher candidates.

6.4.1 Finland's system leaders aim to encourage collaboration

The Ministry of Education and Culture in Finland works closely with initial teacher education providers to build capacity. The Finnish initial teacher education system is characterized by a small number of autonomous initial teacher education providers that collaborate with each other and the Ministry of Education and Culture. The close relationship the Ministry of Education and Culture has with providers ensures system leaders have influence over initial teacher education quality without the need to regulate and constrict provider autonomy.

The collaborative relationship is possible partially because of the small number of providers and the government funding (and limiting) of initial teacher education spots for student teachers. This means that there is not much of a culture of competition between initial teacher education providers. The Ministry of Education and Culture has the goal of disseminating quality evenly between the providers and does not see a need to rank providers in quality or create "top" providers.[259]

Collaboration with deans helps with initial teacher education enrollment projections

The Ministry of Education and Culture has the opportunity to regularly meet with initial teacher education deans since the number of providers is limited to eight. Annually, the Ministry of Education and Culture has formal conversations with each dean to discuss disseminating good-quality practices across universities.

The Ministry of Education and Culture limits the number of initial teacher education spaces based on workforce projections. The Ministry of Education and Culture also discusses these projections with initial teacher education providers to collect and discuss workforce information relevant to the quota-negotiation process, which takes place every four years. A range of information feeds into this process, including survey data collected by Statistics Finland and universities' own enrollment data and assessment of their likely needs into the future.

The Statistics Finland data is highly detailed, including employment data, information on the average retirement age, the average size of teachers' classes, and the amount and type of professional development they have participated in since the last survey.

Together, the information provided to the Ministry of Education and Culture by Statistics Finland and the universities helps the Ministry of Education and Culture determine how many teachers will need to be trained to meet the national demand for education. The universities have the autonomy to decide their own program allocations within the funding for placements allocated by the Ministry, but they typically take the Ministry's advice on whether they are over or under producing particular types of teachers.

For example, Finnish universities are currently overproducing history teachers, which has lowered the employment rate of teachers trained to teach history. As such, the Ministry of Education and Culture is engaging the universities to decrease their intake of history teachers.[260]

Strategic funding

The Ministry of Education and Culture also provides strategic funding to initial teacher education providers to build capacity in specific areas (e.g., developing second language teachers). The Ministry of Education and Culture approaches this process in a manner consistent with the culture of autonomy of providers, inviting universities to help set the direction for strategic funding. It is typical for one or two universities to take the lead on initial teacher education reform strategy in consultation with the other universities.

The government has also designated $50 million euros for the Ministry of Education and Culture to work on initial teacher education reform with the Trade Union of Education in Finland (OAJ) and the universities, polytechnics, the association of Finnish local and regional authorities, and the Teacher Student Union of Finland as part of a series of forums. The forums, which involve around 60 members, will be held over two to three years to set goals for specific areas of reform.[261]

Evaluation with the goal of support

Even though initial teacher education providers have ample autonomy, every department of teacher

Box 14 Initial Teacher Education Evaluation Process in Finland

1. **Upfront collaboration:** Finnish Higher Education Evaluation Council A-Z and initial teacher education provider work together to establish time frame, targets, and procedure for an audit (which occurs once per decade).
2. **Self-evaluation:** The initial teacher education provider completes as a first step.
3. **Site visits:** The Finnish Higher Education Evaluation Council-appointed audit team visits the initial teacher education provider, staying three to five days depending on the size of the institution and the agreed scope of the audit.
4. **Report on strengths and areas for development:** The audit team issues a report outlining the strengths of the initial teacher education provider's practice and areas for further development.
5. **Follow-up:** If there are any major issues, a re-audit may be conducted to see if the provider is improving over time.

Source: Adapted Tatto et al (2013), referencing Finnish Higher Education Evaluation Council (2013) education must have a strategy for improving the quality of teacher education programs.[262]

The Ministry of Education and Culture also conducts a comprehensive teacher education evaluation every ten years, with the next evaluation due to begin in 2016. The evaluation process involves researchers looking at the efficacy of initial teacher education and in-service professional education of teachers, and it attempts to predict the future needs of the teacher workforce. The evaluation is facilitated by the Finnish Higher Education Evaluation Council, an independent body that operates under the auspices of the Ministry of Education and Culture. The evaluation process aims to build initial teacher education provider capacity and is not punitive in any way.

6.4.2 Hong Kong's goal is increased competition to improve initial teacher education

Hong Kong has also taken steps to build initial teacher education capacity, though in a context distinctly different from the Finnish one. In contrast to Finland, Hong Kong policymakers describe a market-driven initial teacher education system with a goal of creating competition to induce innovation. Initial teacher education providers have autonomy and academic freedom.

However, Hong Kong's Education Bureau has a similarly strong relationship with initial teacher education providers as Finland's central governing body. The Education Bureau works closely with providers through a number of initiatives to help them improve over time.

Special committees for initial teacher education engagement

The Education Bureau provides professional and secretarial support to the Committee on Professional Development of Teachers and Principals. The Committee focuses on improving teacher professional development across the teacher education pathway.

There is also a subcommittee on initial teacher education within the Committee on Professional Development of Teachers and Principals. The subcommittee engages in professional exchange with initial teacher education providers to review and develop programs and set goals for initial teacher education graduates. Members of the subcommittee on initial teacher education include principals, academics, and parents, and government representatives.[263]

There are two key Committee on Professional Development of Teachers and Principals initiatives in development that aim to improve initial teacher education: T-dataset and T-bridge.[264] These are both structures that will collect data, start dialog with teacher education providers, and issue recommendations based on findings.

T-dataset will attempt to build initial teacher education capacity by strengthening feedback loops between initial teacher education providers and schools. The initiative seeks to survey veteran and new teachers, principals, and school-sponsoring bodies to determine the gap between school expectations and the performance of new teachers. The Committee on Professional Development of Teachers and Principals will feed this data back to initial teacher education providers and use it as the basis of meetings aimed at building capacity.[265]

T-bridge aims to bridge the theory-practice gap when initial teacher education graduates go from academic learning into practical experiences in schools. The project will facilitate better communication between schools and initial teacher education programs. It will also study ways of improving the practicum experience by looking at practices from overseas, such as internships and clinical models.[266]

Strategic funding

Like Finland, the Education Bureau in Hong Kong has a history of engaging in strategic funding to build initial teacher education capacity. Hong Kong has a strong focus on improving teacher language skills and has developed funding initiatives specifically for this subject.

For example, language immersion programs for English and Mandarin teachers are now a part of most initial teacher education programs because of government funding.[267] These programs allow student teachers to study abroad for deeper language learning and have been implemented since 2002.

Quality Education Fund

In 1998, Education Bureau established the Quality Education Fund with HK$5 billion (USD$650 million) to support improvements to education across a wide range of priority areas.[268] Academics from initial teacher education programs often receive grants from the fund to develop research in their field that will have a direct impact on schools. While the fund is not directly targeted at improving initial teacher education, much of the research is related to how to improve teachers' preparedness to teach.

For example, Quality Education Fund funded research into literacy instruction. A large focus of Hong Kong's education reform was to improve reading literacy. "Reading to learn" is one of the new curriculum's four "key tasks." Through QEF, researchers from the University of Hong Kong developed a new approach to teaching and learning Chinese. The new pedagogy moves away from memorization of single, isolated characters towards integrating the way students perceive the meaning and structure of Chinese with the process of reading, writing, and using language.[269]

The Quality Education Fund also fosters stronger partnerships between schools and universities to build teacher capacity and conduct research. Research funded through the Quality Education Fund develops new and innovative ways to implement education reforms within specific school contexts. Schools now have direct access to leading researchers to both develop and spread best practice pedagogy.[270]

Evaluation

Hong Kong also has a centralized process of evaluation for higher education providers. Initial teacher education providers must undertake a self-assessment utilizing staff and student feedback

Box 15 Hong Kong Workforce Planning

Even with the focus on competition, there are still just five initial teacher education providers in Hong Kong, and four providers have government-funded places that are limited based on demand for new teachers. Hong Kong does workforce planning for four critical professions: teachers, lawyers, social workers, and medical professionals.

The Education Bureau advises the funding body, called the University Grants Committee, triennially on the projected demand for teachers. This information facilitates The University Grants Committee's allocation of publicly-funded initial teacher education places to the four University Grants Committee-funded initial teacher education institutions. The University Grants Committee stipulates a certain number of places and then universities bid for a share.

The overall projected demand and supply of teachers is created based on information from the Census and Statistics Department's population projections combined with information from relevant divisions in the Education Bureau (e.g., Curriculum Development Institution, Special Education and Kindergarten Education Division).

Initial teacher education providers are allocated a certain number of government-funded places, but they can decide on their own admission criteria in selecting candidates. Universities may admit students for places that are not government-funded, but this is less common except for one fully self-funding initial teacher education provider.

Source: Correspondence with Education Bureau – December, 2015 and referencing any previous recommendations for improvements. The evaluation process also involves reviews of faculty teaching quality and analyses of student progression, as well as feedback from employers regarding the success of graduates in their careers.[271]

6.5 Teacher educator quality is critical to improving initial teacher education

Teacher quality is critical for student learning. So it makes sense that the quality of teacher educators – those who teach prospective teachers – must be an important factor in how much is learned during initial teacher education, including education of elementary school teachers.[272]

However, little is known about the work of teacher educators and their impact on the development of teachers internationally.[273] Despite the momentum in many systems to reform initial teacher education, little attention has been paid to gathering information about the backgrounds of those in this important role.

Teacher educators have wide variation in experience and practice. The initial teacher education experiences of prospective teachers within the same institution differ markedly depending on which teacher educators they are exposed to. The term "teacher educator" is itself broad and contested. In practice, "teacher educator" can refer to a range of actors from tenured professors of pedagogy to postgraduate students running undergraduate tutorials to school-based staff assisting with classroom-based practicums.

To improve initial teacher education, it is important to consider the backgrounds of teacher educators as well as the structure of their role: how are they supported and what are their incentives to improve teaching?

6.5.1 Teacher educators in Finland are both subject experts and experienced teachers

Prospective teachers studying to teach elementary school in Finland have almost all of their subject expertise classes within the education department of a university. In these departments, the teacher educators have both teaching experience, and also very strong backgrounds in the subjects in which they teach.

For example, professors in the education department at the University of Jyväskylä have at least a master's degree in the subject they are teaching as well as a PhD in education. In this department, professors must have some classroom teaching experience (at least two years). Since prospective elementary teachers take most subject expertise classes with professors with this dual-background, there are not as many issues with subject content being disconnected from knowledge needed for teaching.

All staff at the University of Jyväskylä are expected to know how to teach university-level students. Staff are able to take a broad-based teacher qualification in university pedagogy studies, which involves 25 credits in basic studies in university pedagogy or basic studies in education, as well as 35 credits in pedagogical studies in adult education. The purpose of this study is to "develop a personal,

Box 16 The Special Role of People Who Develop Teachers

It is often assumed that someone who is a good teacher can automatically be a good teacher educator.[274] This might the one reason why teacher educators do not receive much preparation or support for their roles.

For example, a few studies of teacher educators in Europe found that most had not received any formal preparation for the role and often had little support from colleagues with more experience.[275]

This is not just a problem with teacher educators in initial teacher education, but also with school-based staff (e.g., mentor teachers). To improve, systems must begin to recognize that teacher educators need special training and support in order to be best prepared to develop others.

reflective and analytical relationship to teaching and guidance" that will support teacher educators' support of their students.

The breadth and depth of the expertise of teacher educators at the University of Helsinki allows them to comprehensively support the pedagogical development of elementary teachers in a way that would not be possible in many other systems.

It is important to consider which faculties teacher candidates take courses with

The teacher educator role can look different across systems and institutions depending on how the role is structured. Many initial teacher education programs may have teacher educators in separate faculties, with some in the faculty of education and others in different parts of the university for particular subjects. In fact, teacher educators may not collaborate with the education faculty at all (e.g., a professor who instructs future math teachers may reside solely in the math department).

In the high-performing systems, it is common for elementary teacher candidates to take most of their subject expertise courses in the education department. This means that the department houses faculty who are subject experts but have developed their courses specifically for teachers. This structure is sometimes related to the history of normal schools – or colleges solely for teachers – in these countries. For example, Naruto University of Education in Japan still focuses primarily on teacher education.

Depending on the provider, not all initial teacher education courses are taken in the education department. For example, elementary teacher candidates in Finland often choose a minor in which they take courses in the department for that subject (e.g., a biology minor takes courses in the science department). However, all of the core subject expertise courses are housed in the education department.

This is different than some initial teacher education programs in the United States, where many core subject expertise courses are actually outside of the education department. This can be a problematic structure as it means that faculty who are instructing teachers may not have a background in the knowledge that is required for teaching. It also sometimes means that elementary teachers are not learning the foundational content most relevant to their level of teaching because they may be taking courses more geared toward advanced concepts needed for general university students.

Box 17 Internal Capacity Building at the University of Jyväskylä

Teacher educators in Finland have the autonomy to structure their own courses and have significant input into the structure of the degree itself.

Staff at the University of Jyväskylä took the opportunity to build their own capacity during the recent development of the new class teacher curriculum.

Revised every five years, the elementary teacher curriculum sets out what elementary teacher candidates will be taught at the university. This time, however, education faculty staff decided they did not just want a new document – they wanted to fundamentally overhaul their operating culture.

Drawing on student feedback and their own experiences, staff decided they wanted to increase collaboration with schools and between faculties to build the capacity of teacher candidates and teacher educators alike.

There is now a strong focus on teacher collaboration and cross-discipline connections at the university, with staff working together to develop curricula. The new curriculum requires teacher educators in all subject areas to work together to deliver integrated content, including through co-teaching.

7 Subject-specific Support in Schools

Initial teacher education can provide a strong base of subject expertise for teachers before they enter schools. However, it is unlikely that initial teacher education can fully prepare a teacher for all of the realities of a classroom environment. This is why in-school supports for teachers are critical: new teachers need to continue to develop subject expertise and fill in knowledge gaps as they adjust to full-time teaching.

Teachers have a great opportunity to develop while teaching because they see immediately the impact of new knowledge on changes to practice and student learning. However, many beginning teachers enter schools without support or resources to help them improve. In the U.S., it is common for new teachers to enter schools with little access to helpful instructional materials and little ability to learn from experienced teachers through lesson observation.[276]

Finland, Japan, Shanghai, and Hong Kong each have different ways of making sure teachers are supported, especially in their first few years of teaching. Japan and Shanghai in particular have strong cultures of professional learning in schools that focus on developing subject expertise through a culture of lesson observation and lesson study.

7.1 Induction

Many elementary teachers, on their first day of teaching, assume full legal and pedagogical responsibility for the dozens to hundreds of students in their classes. They often have to individually create assessments and instruction materials, which is difficult for any new teacher, but particularly for teachers who teach many subjects. While these teachers have a base of subject expertise from initial training, even the most prepared teachers still have knowledge gaps that can start to be filled during intensive induction programs.

It is well established that new teachers are generally less effective at raising student achievement, and many teachers improve dramatically in their first few years of teaching.[277] Induction programs can have a significant influence on how fast early career teachers develop.[278]

U.S. schools often have induction programs, but for elementary teachers, many are focused on general teaching responsibilities and do not involve much subject expertise development. Since the first years of teaching involve getting to know student thinking and learning, guidance in subject-specific issues to improve pedagogical content knowledge can make a big impact. Shanghai, Japan, and Hong Kong provide examples of how induction programs can help teachers develop subject expertise and prepare teachers for lifelong professional learning in schools. These programs are for all teachers, not just elementary teachers, but they are a key factor in the quality of elementary teachers. Finland's intensive focus on standardizing pre-service training has meant that induction was not a priority. The country is, however, now working on improving induction and professional learning in schools.

7.1.1 Teacher induction in Japan is focused on subject expertise

Each prefecture in Japan is responsible for developing an induction program for new teachers. Established in Japanese national law since 1989, all newly hired teachers are required to complete these programs.[279]

Box 18 What Makes Induction Effective?

A good induction program is characterized by much more than administrative and social support from a more experienced "buddy."[280] These components have a large impact on teacher practice:

- Having a highly effective, trained mentor from the same subject area to support with subject-specific pedagogical practice[281]
- Having the opportunity to collaborate and jointly plan units of work with colleagues in the same subject area[282]
- Seeing effective instruction modeled in a range of settings and being observed by others[283]

The content of the programs is determined by the education boards, but typically includes a strong focus on subject expertise development through lesson study. Frequently, prefectures use a mix of in-school and out-of-school programs to induct new teachers. Induction is highly coordinated, with principals, municipal boards of education and prefectural education boards each playing a role in encouraging subject expertise development.

For example, the one-year induction program in the Tokushima prefecture requires at least 150 hours of school-based training and 19 days[284] of external training. In school-based training, new teachers interact with a home-school training supervisor as well as a hub-school training supervisor. The hub-school supervisor trains four new teachers from various schools and coordinates with the home-school supervisor at each school. All supervisors help new teachers develop subject expertise through lesson observations and lesson advice.

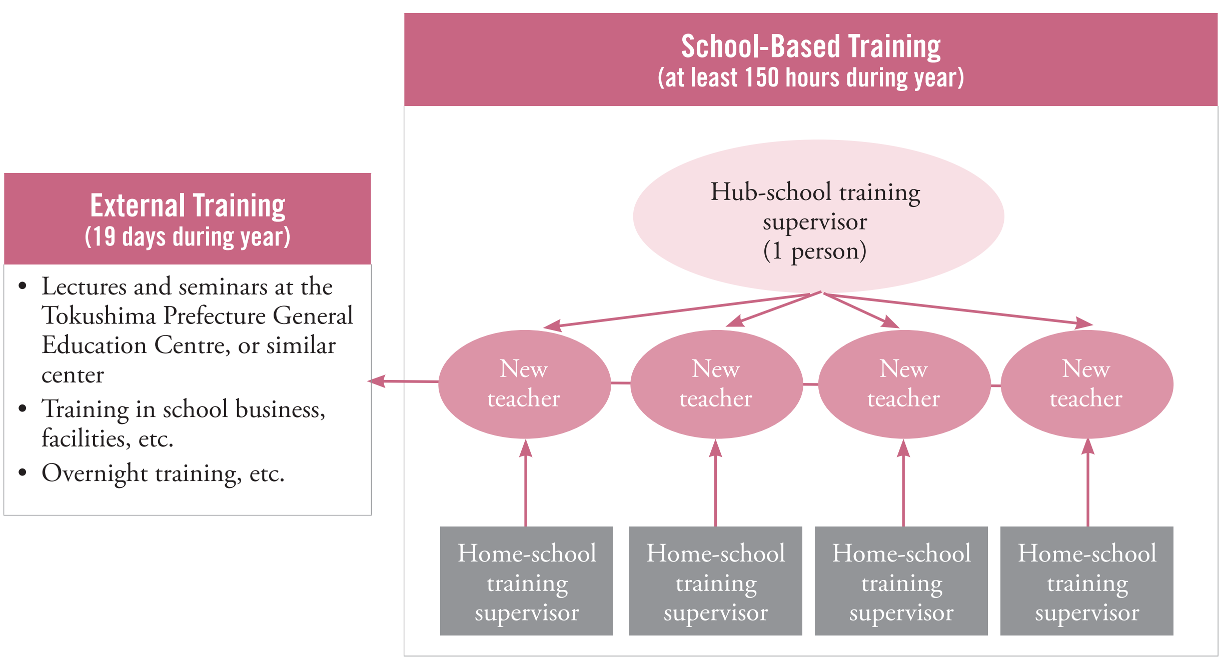
The home-school training supervisor is selected from the school's current teaching staff. There is one home-school training supervisor per school. The principal can reduce the training supervisor's class management workload and teaching hours in order to ensure they can supervise and advise the trainee smoothly. The hub-school training supervisor is appointed by the prefectural board of education.

Both supervisors observe new teacher lessons, give lesson advice, and plan school-based training as part of the induction program. The school-based supervisor is responsible for keeping records of all of the training, and the hub supervisor is responsible for organizing substitute teachers to replace new teachers when they attend external training.

The Tokushima induction program also requires principals to establish a school-wide cooperative structure to manage the induction program (e.g., a committee). The school-based supervisors hold coordination meetings for every staff member involved. This ensures new teachers and supervisors have time for ample lesson observation, discussion, and analysis – all of which greatly improves subject expertise.

School-based training follows a rigorous curriculum of lesson observation and analysis to develop subject expertise.

Figure 15 Tokushima Prefecture (Japan) School-based and External Training Induction Program Requirements



Source: Tokushima Prefecture Board of Education, 2015

Box 19 Expert Teachers Help New Teachers Develop Subject Expertise

In 2015, there were two new teachers being inducted at Sako Primary School in the Tokushima prefecture. A senior teacher with 32 years of experience spent three days each week with the new teachers at Sako (and two days with new teachers at a different school).

New teachers also have access to school-based mentor teachers who are appointed by the school principal. One of these mentors is the science curriculum coordinator who has 31 years of teaching experience.

These supervising teachers do not get much additional compensation for their special role – only about 10,000 yen ($83 USD). However, the appointment is very prestigious and signals a recognition of their expertise.

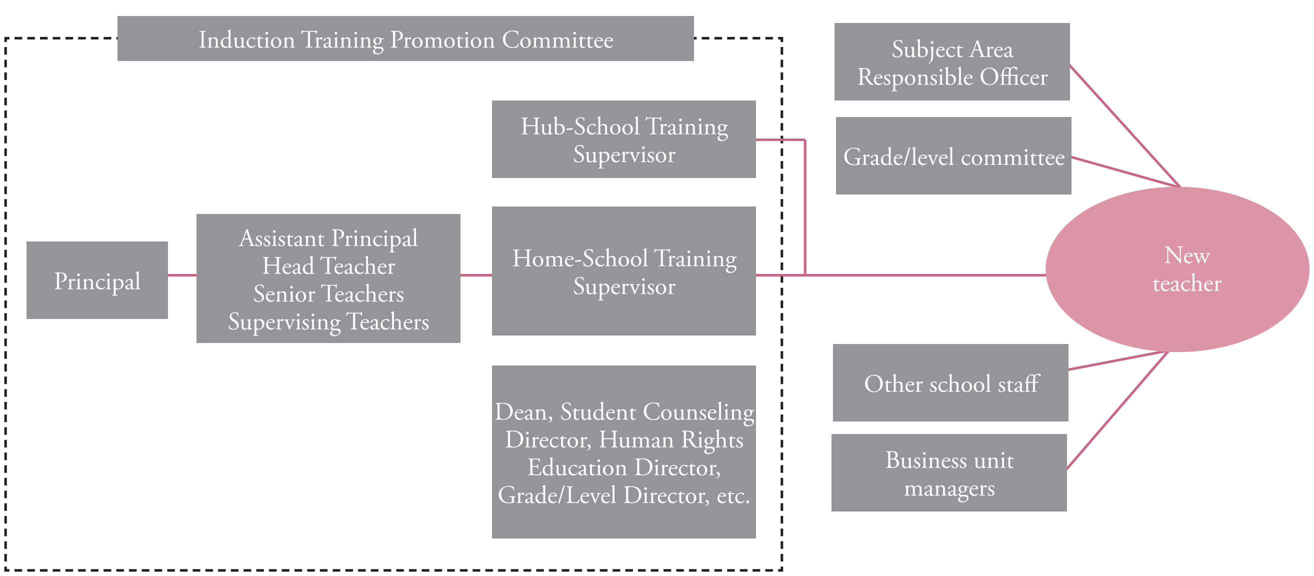
As seen above, Japanese induction programs require involvement from most senior school staff. The programs also include a detailed curriculum of training to prepare new teachers, which includes many hours of time for lesson observation and discussion (which helps build subject expertise). Each prefecture can devise programs differently, but most require many hours of dedicated school time for new teachers to interact with their supervisors.

In Tokushima prefecture, there are two components of the school-based training (which must include at least 150 hours over the year):

- **Lesson Study:** At least 90 hours over the year or about 3 hours per week
- **General Training:** At least 60 hours over the year or about 2 hours per week

Lesson study includes a significant amount of time on lesson observation; both the new teacher observing expert teachers and expert teachers observing and giving feedback to the new teacher.

Figure 16 School-based Induction Committee in Tokushima Prefecture



Source: Tokushima Prefecture Board of Education, 2015

(See more on lesson study in the next section). For example, the requirements include:

- 20-30 hours of peer lesson observation
- 30 hours of being observed by mentors, with mentors co-teaching as necessary
- A requirement that the new teacher observe 10 percent of the school's other teachers giving lessons
- 30-50 hours of discussion with a mentor, which may be a time where teachers discuss the lessons they have observed and synthesize learnings
- Three research classes per year, where the supervisor and trainee teaches in front of their peers

The amount of time spent on observation and discussion during induction sets teachers up well to have continued participation in lesson study, which is the main platform of teacher professional learning in Japanese elementary schools.

In addition to lesson study, the general training requirements include sessions with supervisors on:

- Basic teacher responsibilities
- Subject-specific instructional techniques
- Use of teaching materials
- Facilitating student activities
- And other aspects of the teacher job

More induction program details from Tokushima are in the Appendix.

The training requires a significant portion of the new teacher's schedule to be allocated to induction. It is discouraged for teachers to have meetings after school, so all of these requirements must be met during school hours. A new teacher might therefore have a few nonteaching days each month to attend external training and will have regular meetings with supervisors scheduled in to the school timetable.

As part of the induction program, new teachers also create their own development plan (in consultation with the supervisors), which can be partially tied to subject expertise development.

The board of education is responsible for monitoring the quality of the induction program, and board staff members have a close relationship which each school principal.

7.1.2 Hong Kong's induction focuses on pedagogical content knowledge through practice, observation, and reflection

Hong Kong's Education Bureau, in conjunction with the Hong Kong Teacher's Centre, provides a three-day induction for new teachers. The induction consists of both subject-specific topics and general topics such as classroom management and communication with parents.

The Education Bureau also provides a detailed Induction Tool Kit for schools to use to induct their new teachers. The Tool Kit was created through a three-stage pilot scheme that involved 47 schools. The Tool Kit provides a recommended schedule for a new teacher's pedagogical and professional development, including learning to work with students and supporting subject expertise. Specifically, the induction year recommendations include:

- Teaching at least 360 periods (or 210 hours) with at least 240 periods (or 140 hours) in the new teacher's major subject area.
- Observing at least two lessons in the new teacher's major subject taught by peers/ mentors and having at least two of their major subject classes observed (with pre- and post-observation discussion).
- Conducting at least four reflection exercises on the effectiveness of learning and teaching in the new teacher's classes.
- With the mentors' support, creating content for at least two areas of student exams in the teachers' major subject area and reflecting on student performance in these parts of the exams.

- With mentors' support and sharing, following through in-depth at least one case study with self-reflection on student development, focusing on students' whole-person development or specific aspects of student development.

Importantly, the Education Bureau specifies the kit is not to be used as part of a performance management process: "The entire process of teacher induction as recommended in the Teacher Induction Scheme is to empower beginning teachers rather than regulate them."[285]

7.1.3 Shanghai

All of the following are based on Jensen, Sonnemann, Roberts-Hull, & Hunter, 2016

Beginning teachers in Shanghai complete an intensive training program during their first year in order to become a fully certified teacher. The professional learning they engage in during induction is heavily related to their subject expertise: they are assigned mentors who are subject experts and they participate in collaborative groups observing lessons and developing teacher research skills.

Figure 17 New Teacher Professional Learning in Shanghai

	Activities	Frequency
School-based training at 'home school'	**Training and support within own school** Mentoring • Devise training plan • Review and modify lesson plans • Observe each others' lessons Lesson observation • Observe others and write report • Observe and comment on colleagues' classes • Be observed in official 'teaching trials' by home and base school mentor Lesson groups • Design and moderate one activity • Deliver demonstration lesson (under mentor guidance) Personal reflection on professional experience as a probationary teacher Lesson planning – curriculum and assessment Analyse one unit of teaching materials and lesson plan preparation Design the homework of one unit and explain Design and quality test units Conduct quality analysis of mid-term and final exams	 Once per year 4-8 per semester Once every 2 weeks (minimum) 10 times per year 3 times per year 3 times per year Once per year 2-4 times per year 10 essays per year 3 times per year 3 times per year 1 time per year 2 times per year
Training at a high-performing 'base school'	**New training component since 2012** • Beginning teachers attend a high-performing school • Assigned a mentor • Activities include shadowing a mentor, participating in research groups and lesson observation	Up to 3 half days per week
District standardised training program	**Details of training program** • Workshops and seminars including lesson preparation, homework design, how to conduct lesson observation, curriculum design • Self-study	Once per month
Evaluation	**Evaluation details** • Evaluation by home and base-school mentors • National written test • Interview	End-of-year assessment

Source: Jensen et al., 2016

Beginning teachers have two mentors: one for classroom management and one for subject-specific guidance. Mentors may be experienced teachers within the 'home' school, or master teachers who work across the district.[286]

Beginning teachers undertake intensive school-based training not only in their home school, but also at a high-performing school in their district. At the home school, mentees engage in regular lesson observation with their mentor at least once every two weeks. They work with mentors in developing teaching plans and assessment design. Mentor teachers observe and evaluate beginning teachers' lessons at least three times per year.

A significant portion of beginning teacher induction takes place through collaborative groups in the school. Beginning teachers are active participants in these groups and must lead discussions within the groups one to two times per semester with mentors and other teachers providing feedback.

Beginning teachers also visit a high-performing school in their district up to three times per week, where an experienced teacher mentors them. Teachers observe regular lessons as well as collaborative lessons. The school provides training on how to conduct research and how to write a research paper. In addition, district training consists of face-to-face seminars and workshops held one weekend per month, and network-based teaching that teachers conduct themselves.

This training develops foundational subject expertise skills and an awareness of how to engage in research and lesson observation to continually improve.

At the end of the year-long program, beginning teachers must pass an evaluation to become fully certified. The evaluation includes a national written test, an interview, and teaching a sample lesson.

7.2 Instructional materials

Novice elementary teachers, especially those who teach many subjects, need to be able to rely on quality instructional materials in the same way they rely on quality induction programs and subject mentors. New teachers will not yet have developed high levels of subject expertise in every subject, so having quality instructional materials is a useful way to bridge the knowledge gap.

Some teachers use instructional materials as a backup option when they are unfamiliar with content, and others use them more frequently. A teacher's use of textbooks, for example, varies based on the subject matter being taught, trust in the textbook, and knowledge of the subject matter.[287]

Instructional materials can include curriculum documents, textbooks, teacher handbooks, example lesson plans, etc. These materials not only influence teachers, but students also have a direct interaction with them in the form of textbooks and problem sets. Multiple large-scale studies have found that the choice of instructional materials can have a big impact on student learning.[288] The effect sizes of better instructional materials may even be large enough to compare to the effects of having a better teacher.[289]

In Japan and Finland, quality textbooks and other instructional materials are widely used, especially by novice teachers. These materials are considered to be critical teaching tools, and they are trusted by teachers and schools. The materials lay out key pieces of subject expertise within a progression of lessons so that teachers are not forced to design lessons and curriculum from scratch (although they are free to do so if they feel comfortable). Materials are also linked to a strong, centrally established curriculum and are regularly updated by respected teachers and teacher educators.

In the U.S., however, there are issues with quality of instructional materials and school curricula. Schools do not have good information on which curricula is the most effective. A U.S. study of curricula chosen by Indiana schools showed that while there were large differences in the effectiveness of different curricula, more effective curriculum were not the more popular curricula. It was found that the publisher of the least effective curriculum did not become less popular over time, partially because the school and district decision makers lack information about effectiveness.[290] Most elementary school mathematics curricula examined by the U.S. Department of Education's Institute of Education Sciences What Works Clearinghouse either have no studies of their effectiveness or have no studies that meet reasonable standards of evidence.[291]

"The design and spread of curriculum material is one of the oldest strategies for attempting to influence classroom instruction."

– Loewenberg Ball & Cohen, 1996[292]

7.2.1 Japanese textbooks and teaching manuals

In Japan, teachers are expected to follow the Course of Study issued by the Ministry of Education – which is a set of broad standards for each grade.[293] The Ministry of Education has strict control over textbook quality and content as part of an approval process. But the prefectural boards of education select the instructional materials for each prefecture (as long as they have been first approved by the Ministry of Education).[294]

The instructional materials are available to all teachers, but there are no requirements that teachers use them. Teachers can use teaching manuals for each lesson that are from the textbook company. It is up to the teachers how they use the manual – they may refer to it more with an unfamiliar topic, but for some lessons may not use the manual at all.[295]

It is common for initial teacher education programs to focus on studying the national curriculum and teacher guides as part of subject expertise courses. At Tokyo Gakugei University, it is recognized that teachers need to understand how individual lessons fit within the overall curriculum and link to the Course of Study standards.[296] Mentor teachers also advise new teachers how to use the teaching materials. For example, the Curriculum Coordinator in Sako Primary School (Tokushima Prefecture) spent time during the summer training new teachers on how to use the teaching materials before they began teaching at the school.[297]

7.2.2 Finnish textbooks

Teachers in Finland are well-known for having a high degree of autonomy with an education that prepares them to think critically about their practice. So it might be surprising that there is a strong culture of textbook use in lesson planning. There are no requirements that teachers follow textbooks, but many Finnish teachers – particularly new teachers – have a high regard for the instructional materials that are available to them and use them frequently. Trainee teachers are encouraged to use their own imagination to develop high-quality, curriculum-related teaching and learning materials, and then use the published materials to supplement these where necessary, likely for topics in which teachers have subject expertise gaps.

High-quality curriculum materials are made available to teachers in Finland throughout their career in the classroom. There is an open market for the publication of materials in Finland, though in practice there are just a few key trusted publishers of curriculum-related materials and activities. Schools can choose their textbooks from any publisher. Publishers hire experienced and trusted teachers to write the textbooks and are members of the curriculum-steering group so that they can align the materials they produce to what is taught in schools.[298]

The teacher manuals that come with the textbooks often have theoretical and conceptual content knowledge for teachers about the subject. For example, a textbook for English instruction includes a chart of how the learning path works for second language acquisition, examples of how to differentiate in class, and sample games for the teacher to use.[299]

In initial teacher education, subject expertise instruction focuses on familiarizing teachers with the curriculum and instructional materials. For example, a literacy course at the University of Helsinki includes tutorials where students are introduced to textbooks and learn how to utilize them as cognitive tools. The prospective teachers are encouraged to ask questions about why the books were composed in particular ways – to better understand how to use them in instruction in a way that supports pedagogical practice.[300]

7.3 Professional learning

Teacher subject expertise is developed over time, improving with each lesson and student interaction. Although it is important for teachers to have a strong foundation of knowledge from initial teacher education, much of their subject expertise will be developed in schools. Professional learning initiatives are critical to the development of knowledgeable teachers.

Unfortunately, many professional learning programs have failed to bring about much improvement in teacher practice and student learning.[301] This is often because professional learning is structured as isolated workshops that offer little connection to a teacher's actual practice. For the development of any skill, targeted and sustained professional learning is important, but it is particularly necessary for the development of subject expertise, which requires many cycles of planning, teaching, and feedback for deep learning.

Too often, elementary schools focus only on professional learning for generalized skills, like general pedagogy. Even when teachers are generalists, there are often one or two subject areas in which teachers could benefit from specialized professional learning.

The systems studied in this report have subject-specific, targeted, and sustained professional learning for both generalist and specialist elementary school teachers.

7.3.1 Japanese lesson study develops subject expertise

Almost all Japanese elementary teachers engage in an ongoing professional development project – lesson study.[302] Lesson study allows teachers to critically analyze teaching to develop knowledge about what works best to help students learn. The goals of lesson study are broader than just improving one lesson: teachers engage in discussion and lesson observation as part of lesson study to improve their overall subject expertise and particularly pedagogical content knowledge.

Lesson study is a shared process where teachers work collaboratively to develop, teach, analyze, and refine lessons, and has a long history in Japanese schools (over 120 years).[303] It has an explicit focus on student learning goals and is designed to incrementally build subject expertise across an entire teaching staff.[304] Groups of teachers explicitly set goals for student learning and work towards it through a cycle of research, practice, and reflection.

Lesson study integrates various types of teacher knowledge, creating a context where teachers can simultaneously develop and apply knowledge and skill.[305] Through collaboration with teachers of varying levels of expertise, younger teachers are able to benefit from the subject expertise held by their peers.

Lesson study themes are generally set by a school; for instance, one year's study might focus on mathematics. A schedule for lesson study is set at the beginning or the end of the year.[306] The lesson study itself typically consists of a small group of teachers choosing a topic for the study within the school's theme. This is selected through teachers' analysis of current student learning issues. For instance, a math lesson study group might determine that students are confused about whether zero is an even or odd number which signals that students do not

Figure 18 Lesson Study Cycle

Source: Adapted from Lesson Study Research and Practice in Mathematics Education, 2011 have a precise understanding of the concept of even numbers. This conversation among teachers helps develop their own pedagogical content knowledge in math, at the same time they are refining lessons for their students.

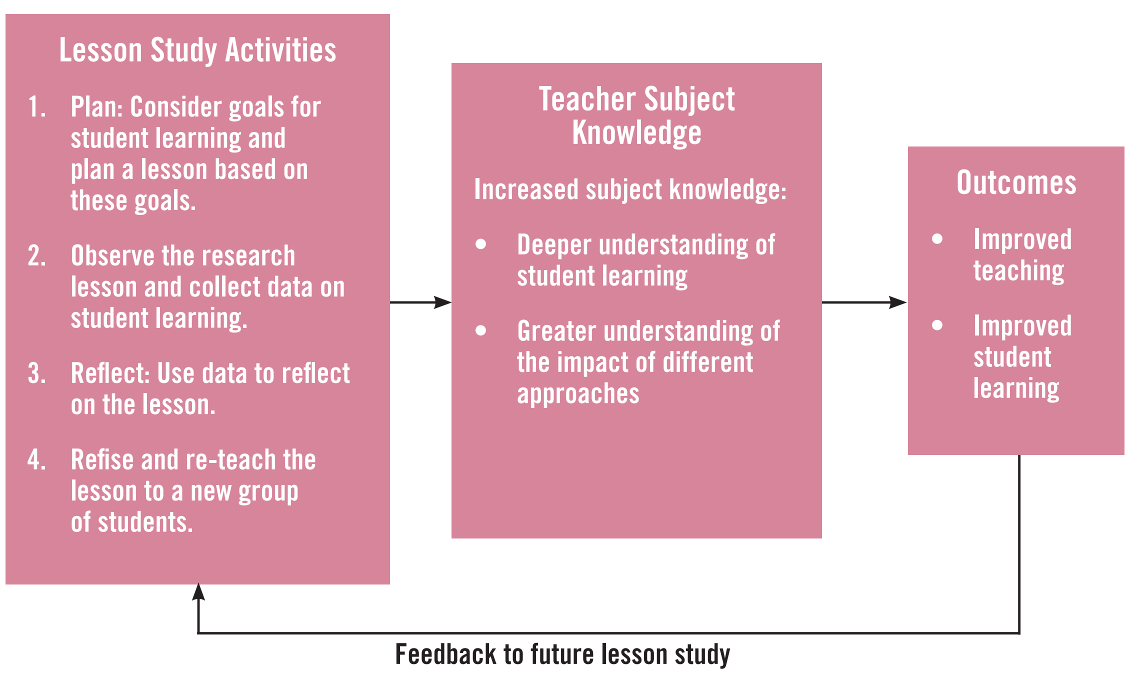
Next, teachers collaboratively plan a lesson that tests a preferred approach to the topic. The goal is not just to create an effective lesson, but for teachers to understand *why* the lesson works.[307] This understanding is part of pedagogical content knowledge. Teachers may read and discuss materials prepared by other teachers outside their school, as well as textbooks and teaching manuals addressing similar problems. A tentative lesson plan might be presented to the staff of the entire school for feedback.[308]

During lesson planning, the group discusses how students might understand the topic and tries to anticipate their approaches to problem solving. Often, the lesson study focuses on the use of a specific example. For instance, teachers might consider which combination of numbers is best to use to start a lesson on subtraction; e.g., 13–9 or 14–8. Teachers might propose that 13–9 or 12–9 are the best examples to introduce students to the basic concept because students can more easily subtract 9 from 10 and then add the remaining numbers. Using an example like 14–8 might prompt more argumentation in the class.[309]

Once a lesson has been planned, one or more teachers teach the lesson observed by their peers. The group typically also records the class. Then, they discuss and reflect on what might be improved. A revised lesson may be taught by another teacher in the lesson study group. Lesson study may involve 10-15 hours of meetings, spread over a few weeks to a month.[310]

Lesson study is implemented continuously in Japanese elementary schools, though the frequency varies. According to a 2010 survey by the Ministry of Education, 99.5 percent of elementary schools implemented a lesson study process at least once per year, and 83 percent at least five times per year, and 21 percent least 15 times per year.[311]

Figure 19 How Lesson Study Develops Teacher Subject Expertise in Japanese Schools



Source: Interviews with Japan, November 2015

7.3.2 Shanghai develops and rewards subject expertise

Shanghai is known for its strong culture of teacher professional learning, which might be one of the reasons for the system's success.[312] Much of Shanghai's professional learning system is structured to develop subject-specific expertise. Each teacher has access to a mentor, who is an expert in the same subject. Teachers also participate in research and lesson groups, which allow teachers to engage in research that develops pedagogical content knowledge. As teachers develop, they are recognized and rewarded for their increasing expertise and have a responsibility to mentor younger teachers in the same subject as they move up the career ladder.

Shanghai's teachers develop research skills though learning communities

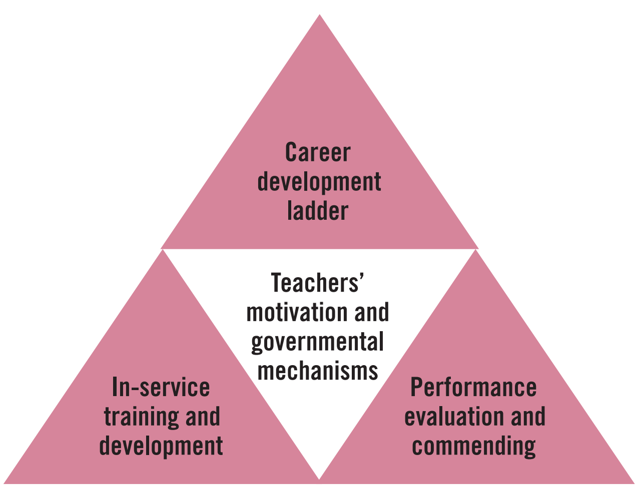
Two types of learning communities – "teaching and research groups" and "grade groups" – are at the heart of Shanghai's professional learning culture. Teachers meet with both of these groups each week. Research and lesson groups are for all teachers of the same subject, and grade groups are made up of all teachers in the same grade. Since all elementary schools are departmentalized, both elementary and secondary teachers participate in a research and lesson group for the subject they teach.

Box 20 Research and Lesson Groups in Shanghai[313]

Research groups are comprised of teachers of the same subject across a whole school.

Lesson groups involve teachers of the same subject within one grade level. Lesson groups are basically smaller versions of research groups.

Figure 20 Model of Teacher Development and Progression in Shanghai



Source: Zhang, Ding, & Xu, 2016

The Shanghai research and lesson groups are a good example of a formal professional learning structure that works to improve teacher subject expertise. Of course, many schools in other countries (e.g., in the U.S.) have time set aside for teachers to meet with other teachers of their same subjects or grade levels. But rarely do these teachers interact like Shanghai research and lesson groups: with classroom observations, academic research, and critical feedback.

Teachers in research and lesson groups begin by choosing a particular topic of interest related to improving student learning. They look at school objectives and analyze data on student learning to choose a research topic that will improve teaching and learning in their school. This topic is usually set for a whole semester or whole year. Teachers then begin to research teaching methods to address the topic being covered. It is very subject specific so teachers are continually developing their pedagogical content knowledge. Teachers read and discuss literature and hold forums with university experts and retired master teachers. Most of the semester is spent testing out new methods while being observed by other members of the group in order to get feedback and collect information on how well the new methods are working to improve student learning.

The results of these research groups are often formally published as teacher research. This is a crucial part of teacher career development in Shanghai; the public recognition of the development of elementary teachers' subject expertise.

Box 21 Steps Followed by Research and Lesson Groups

1. Set research question based on student learning.
2. Review existing research on methods of teaching the subject, addressing the research question.
3. Prioritize teaching strategies based on discussion with group.
4. Test strategies in class; observe and discuss each other's lessons.
5. Analyze evidence, identify what worked (and what didn't), and publish results.

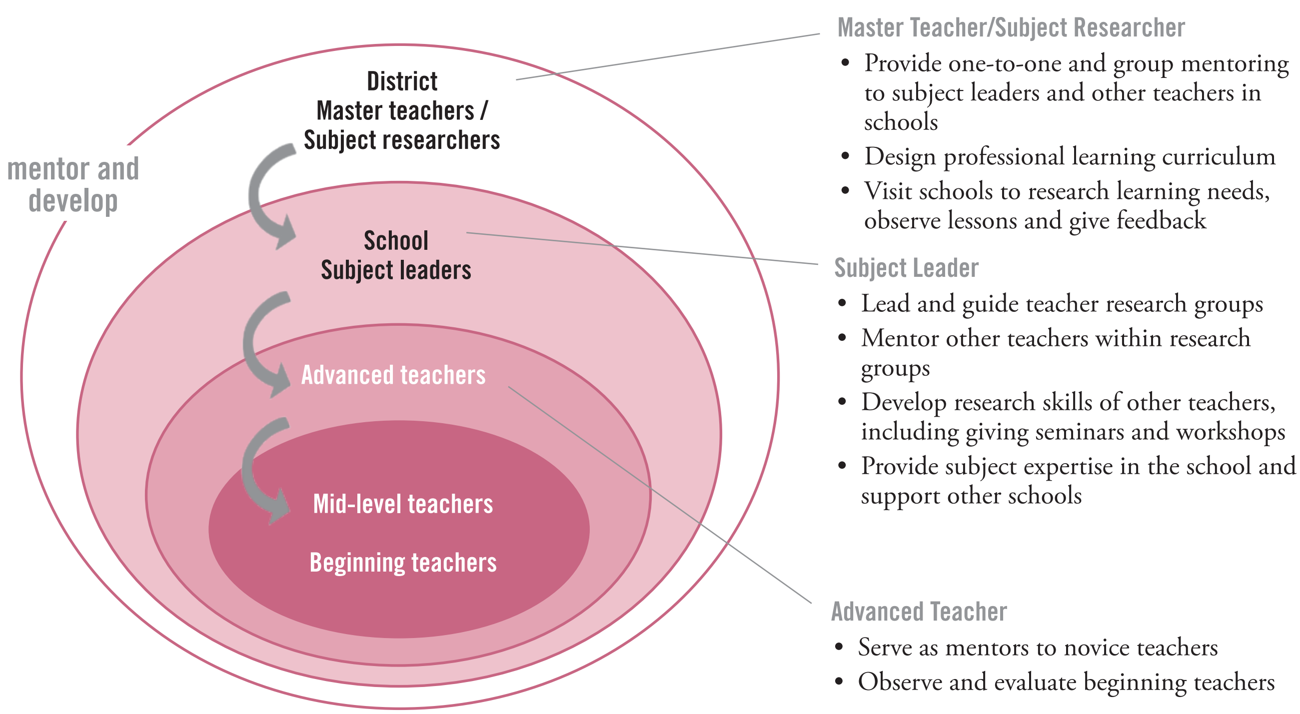
Adapted from Jensen et al., 2016

Schools support research and lesson groups by setting aside specific time for group work, and teachers have physical office space for their research and meetings with the group. Leadership within subjects and of research and lesson groups is important and recognized throughout the system. Group leaders are paid extra for their role. This leader also acts as an expert to coach more novice teachers. Lesson plans, teaching materials, and research findings are uploaded online for all teachers to access.[314]

Leaders are chosen and evaluated on their subject expertise and contributions to developing subject expertise in other teachers, across their school, and also across the system. A teacher's contribution to research group activities, as well as the achievements of the group as a whole, are factors in a teacher's formal evaluation which is the basis for promotion decisions.[315]

Principals give teachers feedback as well as financial incentives to improve the quality of their research articles. Principals may also provide information about appropriate publishers and develop school-based book collections for teachers.[316]

Figure 21 Mentoring Roles of Subject Experts in Shanghai



Source: Jensen et al., 2016

Schools operate in networks to share knowledge gained from their research groups. There are also research functions at district and municipal government levels that conduct their own research and publish and promote school-level research.

Subject experts are expected to mentor younger teachers

Shanghai realizes the importance of subject-specific mentoring and invests in developing subject experts to lead professional learning. Teachers are assigned subject mentors and they can also access advice from the school subject head or research group leader. This way, a young science teacher on her first day teaching can see a clear line of subject-specific support and expertise through the system which can help her build her own knowledge.[317] Mentees evaluate the effectiveness of their mentors through 360-degree feedback. Mentors will not be promoted to the next level unless they receive positive feedback from the teachers they have mentored.[318]

Career ladders reward subject expertise and encourage development of expertise

For most systems, the only way teachers can get promoted is if they decided to move into school administration on the way to becoming a principal. This means that developing subject expertise is not really rewarded, and there is no official subject expert in the system. Shanghai is different in that it has developed a career path for teachers to become subject experts. Teachers can be rewarded for improving their subject expertise, and as they are promoted, they are responsible for developing the subject expertise of other teachers throughout the system.

In order to be promoted, teachers must display not only teaching competence but also skill in academic research related to teaching. They are expected to publish professional papers or other research results in publications at the district level and above. Teachers must have at least five years of experience before they are promoted, but experience alone

Figure 22 Progressive Teacher Mentoring and Development Roles in Shanghai

Teacher track senior positions	Senior (Advanced) Teacher	Subject Leader	Master Teacher (Subject Researcher)
Required experience	6-10 years of teaching	At least 11 years of teaching experience	At least 11 years performing a senior education officer role
Role in developing others	• Mentor junior teachers • Observe and evaluate beginning teachers • Lead collaborative research and lesson groups • Help set group directions, research questions, methodology, guide group analysis and discussion	• Lead and guide teacher research groups • Mentor other teachers within research groups • Develop research skills of other teachers including giving seminars and workshops • Provide subject expertise in the school and support other schools • Lead content and pedagogy in their subject fields on top of their usual workloads	• Provide one-to-one and group mentoring to subject leaders and other teachers • Design and deliver professional learning curriculum in their subject area • Visit school to research learning needs, observe lessons, and give feedback • Responsible for improving teaching throughout the system in their subject area • Regularly visit school to develop "key teachers" (who are usually subject leaders at the district level)

Source: Jensen et al., 2016

doesn't mean they are automatically promoted.[319] Different aspects of subject expertise development and participation in professional learning are included in teacher appraisal, which is important for promotion. These include:[320]

- Input measures of participation in professional learning, such as the number of hours undertaken (district officials inspect schools to check the hours and type of professional learning undertaken across the school)
- Performance in professional learning, especially collaborative learning groups (this is evaluated through observations of professional learning, peer feedback and 360-reviews)
- Professional learning outputs such as published papers, demonstration lessons, awards, and seminars and workshops, and
- Improvement in teaching evaluated by internal and external observations

Shanghai also has awarded a special status of master teacher to less than half of 1 percent of teachers.[321] Master teachers are the leaders of their subject in the system. Teachers are selected for this permanent title after an evaluation by the Master Teacher Title Committee. The committee interviews candidates about teaching practices and observes their lessons. Master teachers are required to[322]

- be active in reforms of curriculum and teaching,
- have published research extensively and received various teaching awards, and
- have at least 10 years of subject teaching experience.

The municipal government grants winners of the master teacher title, but local policymakers can create additional awards and honorary titles. These include titles such as "new star teacher," "senior advisor," and "subject leader."[323]

8 Conclusions and Implications for the United States

U.S. policymakers, school leaders, and teachers can learn from policies that have worked in Japan, Hong Kong, Shanghai, and Finland. All four systems have structured the preparation and development of their elementary teachers to ensure strong subject expertise.

There is momentum in the U.S. to improve teacher subject expertise by creating better quality initial teacher education programs and overhauling teacher professional learning. It is critical that new policies and programs follow the lessons from high-performing systems to ensure strong teacher subject expertise, which leads to effective instruction and better student outcomes.

Below are some of the key takeaways for U.S. policymakers:

Use selection assessments to ensure quality subject knowledge.

Many in the United States would love to make initial teacher education programs as selective as Finland's. But the United States has a different structure and governance of initial teacher education that may make Finland's selection process difficult to emulate.

The number of students admitted into Finland's initial teacher education programs are government controlled and funded, resulting in fewer candidates in initial teacher education throughout the country. This allows Finland to only select the best candidates into initial teacher education.

U.S. initial teacher education is far less regulated with colleges and universities accepting far more teacher education students than the country needs in any given year. At the same time, these large numbers provide those institutions with a financial incentive to continue to accept large numbers into a program that is less costly to administer than most other university programs. Major structural changes to how initial teacher education providers are funded and regulated would be necessary in order to have uniformly high admissions requirements in these open systems of initial teacher education. While the Finnish system highlights the importance of selection, the Japanese experience may provide an alternative way forward for the U.S. and other countries with crowded initial teacher education markets. Japan placed selection hurdles after initial teacher education at teacher employment. Importantly, these hurdles were successful in improving the quality of initial teacher education and the selection of graduates into initial teacher education.

Japan is an example of an open initial teacher education system, with hundreds of providers. Many in Japan complain that it is too easy to gain teaching credentials, and there are many more certified teachers than there are teacher job openings. However, the Japanese Ministry can't regulate teacher education providers in the same way that the Finnish government can.

So instead of focusing the strongest selection assessments on entry to initial teacher education, Japan created an employment exam. The exam is difficult and many people fail. So Japan has a very rigorous teacher selection process, but unlike Finland, this assessment is at the point of hiring. All teacher candidates applying for teaching jobs must take an employment exam that tests teacher knowledge and ranks candidates, allowing schools to hire only from the top of the rankings.

Consider continuous measures of candidates (or rankings) instead of setting minimum standards for subject expertise

Much of the policy debate on teacher quality focuses on minimum standards. This is limiting. Experience from high-performing systems highlights the benefits of systems that continually develop and recognize subject expertise at all levels of proficiency. This is especially important when developing selection criteria.

The minimum standards approach has two issues:

1. It does not create incentives for development past minimum standards.
2. It does not provide differentiating information to the system on teaching candidate quality (aside from binary pass-or-fail data).

When the assessment ensures teachers (or teacher candidates) meet minimum requirements, actors in the system target minimum standards. Teacher candidates prepare themselves to pass minimum standards; initial teacher education providers design the courses and set quality benchmarks to ensure minimum standards are met. And schools then only employ teachers who meet the minimum standards.

On the other hand, an assessment with a continuous measure of teacher expertise (or one that ranks candidates) focuses candidates on developing the strongest expertise possible. Initial teacher education providers know they must develop deep expertise in all of their teachers, and then schools can more easily differentiate between candidates with more information on which teachers have the greatest expertise. Moreover, if candidate assessment data is made transparent, it provides a serious incentive for the initial teacher education providers and helps teacher candidates make decisions about which program to attend.

This is why rigorous selection assessments at employment that rank candidates can be powerful, particularly when the supply of teachers is much greater than the demand.

For example, Japanese employment exams rank candidates, and teachers are selected from the top of the ranks down.[324] This means there is no "passing" score that ensures a position – only top-achieving candidates will be offered a job. The competition for teaching jobs is high: in 2013, there were 4.3 candidates for every elementary school teaching job.[325]

This process sends a powerful signal not only to teacher candidates but also to initial teacher education providers: teacher subject expertise is assessed because it matters. Initial teacher education courses need to focus on developing deep subject expertise or their graduates will never get high scores in the employment exam. The effect of a continuous measure of expertise leads to a very different series of behavioral reactions and events throughout an education system compared to a focus on minimum standards.

Use specialization to foster deeper subject expertise in elementary school teachers

Teacher specialization is an attractive policy to improve subject expertise because it alleviates constraints on time and resources. If a teacher has to become an expert in one subject, that is considerably easier than becoming an expert in six.

All four systems studied for this report had some form of elementary teacher specialization, but they each took a slightly different approach. Japan and Finland have school structures where teachers teach all subjects, but these teachers are trained more deeply in one or two subjects during initial teacher education and often become leaders in those subjects in the school. Shanghai and Hong Kong have more extensive specialization, with elementary teachers having teaching assignments for only one or two subjects. Both approaches increase teacher subject expertise, and both can be piloted in U.S. schools.

U.S. schools interested in full teacher specialization should look at the lessons from Hong Kong and Shanghai. Although teachers in these systems teach fewer subjects and more students, they also tend to have strong relationships with students through teacher looping. In Shanghai, it is not uncommon for teachers to follow students to different grade levels for three or more years. Enhancing teacher/student relationships with a policy like looping could be a critical part of making specialization work.[326]

If U.S. schools are interested in continuing with generalist teachers, they can follow the approaches of Japan and Finland to encourage teachers to develop deep knowledge in one subject. Schools should be particular about hiring and developing teachers to ensure there is an expert teacher in each subject.

Focus initial preparation on foundational content at the elementary school level

The high-performing systems analyzed had three things in common in their elementary initial teacher education programs:

1. A focus on the foundational knowledge that teachers need to effectively teach the elementary school curriculum.
2. Emphasis on pedagogical content knowledge and not just general pedagogical skills.
3. A high degree of alignment to school curriculum.

Having initial teacher education programs recognize the value of subject expertise doesn't mean that elementary school teachers all have master's degrees or PhDs in their subjects. These systems understand that elementary teachers are better off developing a deep and flexible understanding of foundational content taught in elementary schools rather than just advanced-level content.

Time during initial teacher education programs is limited. For this reason, content courses should be aligned to the level of the curriculum being taught. It is more helpful for elementary teachers to have a deep knowledge of the concepts taught in elementary school rather than a shallow knowledge of advanced concepts taught in a math faculty in Universities and Colleges. This might be an issue for some university-based programs in which content knowledge courses are taken in subject faculties, such as the mathematics faculty, instead of within the education faculty. If a prospective elementary school teacher is fulfilling math course requirements in the math faculty, it is unlikely that these courses will be aligned to elementary school curriculum.

Focus on outputs rather than inputs

Debate about teacher quality and developing subject expertise becomes skewed with an overt focus on inputs: on how many courses a teacher has completed or whether they have completed a master's degree or a PhD. This inputs-focused mindset has led to two problems:

1. A belief that more education is always better (leading to ever increasing costs) rather than focusing on the subject expertise elementary school teachers need to be effective.
2. Research assumptions that equate qualifications with expertise. A number of studies have compared the effectiveness of teachers with different qualification levels (e.g., master's degrees) and found that they don't improve teaching. But higher qualifications do not mean teachers necessarily have more expertise, so these studies cannot accurately predict the impact of increased subject expertise.

This report emphasizes the development of subject expertise in teachers – which is, in part, an output of initial teacher education. This does not necessary imply that systems should increase the quantity of subject expertise courses in initial teacher education or regulate which courses teachers should be required to take.

The fact that a teacher goes through a course actually says little about the amount a teacher has learned. Courses vary significantly in quality. This might explain why there is mixed evidence on the number or type of courses a teacher takes and his or her performance in the classroom.[327]

It is therefore more important for systems not to overemphasize inputs and instead focus primarily on outputs: the amount of subject expertise potential teachers gain and their eventual impact on student learning.

Ensure all teachers continue subject expertise development in schools

Teacher subject expertise is developed over time, improving with each lesson and student interaction. Although it is important for teachers to have a strong foundation of knowledge from initial teacher education, much of their subject expertise will be developed in schools.

Once in schools, subject-specific professional learning opportunities need to increase in quality and quantity. The first few years of teaching are important to develop pedagogical content knowledge, and an induction program with subject-specific collaboration will help. Teachers should also be provided with instructional materials that are research-based and useful for improving instruction.

Unfortunately, many professional learning programs have failed to bring about much change in teacher practice and student learning.[328] This is often because professional learning is set up as isolated workshops that offer little connection to a teacher's actual practice. For the development of any skill, targeted and sustained professional learning is important, but it is particularly necessary for the development of subject expertise, which requires many cycles of planning, teaching, and feedback for deep learning.

High-performing systems make sure teachers have access to a strong induction program, an expert mentor, and collaborative professional learning structures that encourage lesson observation and analysis. Japanese lesson study is one example of a professional learning structure that encourages analysis of student thinking, feedback on practice from a subject expert, and collaborative lesson planning – all of which can improve subject expertise.

Collaborative professional learning structures are not the only thing that can help teachers improve subject expertise. Strong instructional materials can also fill gaps in knowledge and are particularly important during the first few years of teaching.

Continuous evaluation and monitoring

There is no single right way to improve teacher preparation, but there are many promising practices. Given the limited evidence on specific ways to improve teacher subject expertise, experimentation and innovation should be encouraged and supported through strong evaluation. Any trials of new policies in initial teacher education or in-service professional learning should focus not just on the content taught but ensuring prospective teachers are actually learning it by evaluating the impact of new policies on teacher effectiveness.

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35. Niemi & Jakku-Sihvonen, 2011
36. Niemi & Jakku-Sihvonen, 2011
37. Interview with the Finnish National Board of Education, November 2015
38. Niemi & Jakku-Sihvonen, 2011
39. Niemi & Jakku-Sihvonen, 2011

40. Interview with University of Jyväskylä, November 2015
41. Sahlberg, 2014
42. Sahlberg, 2010
43. Interview with University of Helsinki and University of Jyväskylä, November 2015.
44. Shanghai Municipal Education Commission, 2014, OECD, 2010a, p. 91.
45. OECD, 2013b.
46. See Ma, 1999
47. Statistics are for 2010, Shanghai Municipal Statistics Bureau (SMSB), 2011 cited in Zhang, Xu, & Sun, 2014.
48. OECD, 2010b
49. Center on International Education Benchmarking, 2011; Jensen et al., 2016
50. Ingersoll, 2007
51. Zhang et al., 2014
52. Zhang et al., 2014
53. Zhang et al., 2014
54. Interview with Shanghai Normal University, November 2015
55. Zhang et al., 2014
56. Interview with Shanghai Normal University, January 2016
57. Zhang et al., 2014
58. Zhang et al., 2014
59. Jensen et al., 2016
60. This has recently been increased from a 240-hour requirement over 3-5 years. Interview with Min Hang District, June 2014.
61. Zhang et al., 2014, p. 154.
62. Shanghai Twelfth Five-Year Plan.
63. OECD, 2013b, p. 177.
64. OECD, 2013b, p. 65.
65. For 2013/14, Education Bureau, 2014a, Education Bureau, 2014b.
66. Education Bureau, 2014c; Yung Man-sing, 2006.
67. Department of Education, 2012
68. Interview with Hong Kong Institute of Education, February 2016
69. Draper, 2012
70. Draper, 2012
71. Draper, 2012, p. 86
72. Draper, 2012
73. Draper, 2012, p. 88
74. Draper, 2012, p. 88
75. Hong Kong Institute of Education, 2015b
76. Draper, 2012
77. Hong Kong Institute of Education, 2015b
78. Department of Education, 2012, p. 117
79. Interview with Hong Kong Education Bureau, October 2015
80. Advisory Committee on teacher education and Qualifications, 2003, p. i.
81. Advisory Committee on teacher education and Qualifications, 2003
82. OECD, 2013a
83. Ministry of Education, Culture, Sports, Science, and Technology-Japan, n.d.
84. Department of Education, 2012
85. Interview with MEXT, November 2015

86. Numano, 2010
87. Department of Education, 2012
88. Department of Education, 2012
89. Department of Education, 2012
90. Saito, 2013
91. Department of Education, 2012
92. C. Lewis, 2011
93. C. Lewis, 2011
94. C. Lewis, 2011
95. Ministry of Education, Culture, Sports, Science and Technology – Japan, 2015
96. Interview with Tokushima Prefectural Board of Education, 2015
97. Saitama Prefectural Board of Education, 2015b
98. Interview with Saitama prefecture, October 2015
99. Interview with Saitama prefecture, October 2015
100. Interview with Tokushima prefecture, October 2015
101. Toshiya Chichibu & Toshiyuki Kihara, 2013
102. Arani, Keisuke, & Lassegard, 2010; Interview with Tokyo Gakugei University. Lesson study is conducted at a national and regional level in addition to the regular in-school process, but the focus here is on the smaller-scale lesson study in schools.
103. Stigler & Hiebert, 2009
104. Phelps & Schilling, 2004
105. National Research Council, 2010; Allen, 2003; Coe et al., 2014
106. Jüttner, Boone, Park, & Neuhaus, 2013
107. Greenberg & Walsh, 2008; National Research Council, 2010; S. M. Wilson, Floden, & Ferrini-Mundy, 2002
108. National Research Council, 2010; Darling-Hammond & Bransford, 2005; Coe et al., 2014; Allen, 2003
109. Campbell et al., 2014; D. N. Harris & Sass, 2011; Metzler & Woessmann, 2012; National Research Council, 2010
110. Ma, 1999
111. Floden & Meniketti, 2005; D. N. Harris & Sass, 2011
112. Deborah Loewenberg Ball, Hill, & Bass, 2005; Deborah Loewenberg Ball et al., 2005
113. Deborah Loewenberg Ball et al., 2008
114. Kilpatrick, Swafford, & Findell, 2001; Allen, 2003
115. Duschl, Schweingruber, & Shouse, 2007, p. 298
116. Evens, Elen, & Depaepe, 2015
117. National Research Council, 2010, p. 2
118. Grossman, 1990; Kleickmann et al., 2013; Roberts-Hull et al., 2015
119. Ward, Grudnoff, Brooker, & Simpson, 2013
120. Kleickmann et al., 2013
121. Kleickmann et al., 2013; Liston, 2014; Superfine, Li, & Martinez, 2013
122. LeSage, 2012
123. Ma, 1999
124. Evens et al., 2015
125. Kellner, Gullberg, Attorps, Thorén, & Tärneberg, 2011
126. U.S. Department of Education, 2008

127. See Conference Board of the Mathematical Sciences, 2010; Kilpatrick et al., 2001

128. Greenberg & Walsh, 2008

129. Discussion with mathematics teaching expert, Phil Daro, February 2016

130. Kilpatrick et al., 2001

131. See Tchoshanov, 2010

132. Discussion with mathematics teaching expert, Phil Daro, February 2016

133. Bates, Latham, & Kim, 2013

134. Hadley & Dorward, 2011

135. Beilock, Gunderson, Ramirez, & Levine, 2010

136. Ma, 1999

137. OECD, 2012b

138. OECD, 2012b

139. Daro, 2014

140. National Center for Education Evaluation and Regional Assistance, 2010

141. Deborah Loewenberg Ball, 1988; Browning, Edson, Kimani, & Aslan-Tutak, 2014; Kastberg & Morton, 2014; Ma, 1999; Olanoff, Lo, & Tobias, 2014; Strand & Mills, 2014; Thanheiser, Browning, et al., 2014; Thanheiser, Whitacre, & Roy, 2014

142. Deborah Loewenberg Ball, 1988; Olanoff et al., 2014

143. National Center for Education Evaluation and Regional Assistance, 2010

144. Browning et al., 2014; Strand & Mills, 2014; Thanheiser, Browning, et al., 2014

145. Thanheiser, 2009

146. National Academies Press, 2012; Next Generation Science Standards, 2015

147. Gregory, 2009; Gregory & Ellis, 2009; Liston, 2013

148. Hanuscin, Lee, & Akerson, 2011

149. Burgoon et al., 2010; Liston, 2013

150. Diamond, Maerten-Rivera, & Rohrer, 2013

151. Lange, Kleickmann, & Möller, 2011

152. Next Generation Science Standards, 2015; Duschl, Schweingruber & Shouse, 2007

153. Duschl, Schweingruber & Shouse, 2007

154. Next Generation Science Standards, 2015

155. Burgoon et al., 2010; Gregory, 2009

156. Bursal, 2012; Kavanagh, Agan, & Sneider, 2005

157. Gomez-Zwiep, 2008

158. Lucariello & Naff, n.d.

159. Sneider, Bar, & Kavanagh, 2011; Thomas, 2011; Wilcox & Kruse, 2012

160. Hanuscin, Lee, & Akerson, 2011; Nowick et al., 2013

161. Nowicki et al., 2013.

162. Phelps & Schilling, 2004

163. National Research Council, 2010

164. Moats, 1999

165. Example adapted from Phelps & Schilling, 2004

166. National Institute of Child Health and Human Development, 2000; Phelps & Schilling, 2004; Snow, Griffin, & Burns, 2005

167. Snow, Griffin, & Burns, 2005

168. Phelps & Schilling, 2004

169. National Institute of Child Health and Human Development, 2000

170. Phelps & Schilling, 2004

171. Snow, Griffin, & Burns, 2005

172. Correspondence with literacy expert Catherine Snow, January 2016

173. Examples taken from Snow, Burns, & Griffin, 1998

174. The report looked at all studies from 1966 through 1999, and only 11 initial teacher education studies met the criteria to be included in the analysis for the report. The panel found no studies that followed pre-service teachers as they moved into teaching positions, so while the studies may measure improvements in teacher knowledge, none could say how this affected teaching and student learning.

175. National Institute of Child Health and Human Development, 2000

176. Greenberg, Walsh, & McKee, 2015

177. August & Shanahan, 2006; National Research Council, 2010; Lucas & Grinberg, 2008

178. L. Lewis et al., 1999

179. Snow, Griffin & Burns, 2005

180. Correspondence with literacy expert Catherine Snow, January 2016

181. Each state has a different exam and/or passing score, and some (such as the MTEL in Massachusetts) are more rigorous. See also: Sawchuk, 2012

182. Putman et al., 2014

183. Shulman, 1986

184. Educational Testing Service, 2005

185. Hiler & Johnson, 2014

186. E. A. Harris, 2015

187. Hanushek et al., 2014; National Center on Education, and the Economy (U.S.), 2008

188. Hanushek et al., 2014

189. The Finnish National Board of Education, 2014

190. Applicants who took part in phase 1 entrance test for Finnish-language class (elementary) teacher education and those selected for class teacher education. Excludes Finland's Swedish-language university.

191. A translated copy is available in the Appendix

192. Hanushek et al., 2014

193. Schleicher, 2012

194. OECD, 2015a; OECD, 2015b

195. Sahlberg, 2010

196. The Hong Kong Institute of Education, n.d.

197. Hong Kong Institute of Education, 2015a

198. High school students can receive a score of 1, 2, 3, 4, 5, 5*, or 5** for each senior secondary subject – higher scores are better. The Hong Kong Institute of Education set minimum scores for entry into undergraduate places at a 3 for Chinese and English (attained by 60.2 percent and 52.5 percent of high school completers) and a minimum score of 2 in mathematics (attained by 80.1 percent of high school completers). In 2015, the entering cohort had a total score of 20-21 across their 5 best subjects, and prospective teachers seeking to major in English, Chinese or Mathematics required at least a 5 in that subject at a high school level. In 2015 a level of 5 or above was attained by 9.2 percent of students in English, 7.4 percent in Chinese Language, and 13.6 percent in mathematics. Source: Census and Statistics Department of Hong Kong, 2015; Hong Kong Institute of Education, 2015a

199. Hong Kong Institute of Education, 2015d
200. Hong Kong Institute of Education, 2014
201. In Hong Kong, the primary language spoken is Cantonese, so English and Mandarin are often second languages for teachers. In elementary schools, language learning takes between 42 percent-51 percent of total class time, generally with more Mandarin classes per week. The Education Bureau suggests between 25 percent-30 percent of class time for Chinese Language education (about 200-235 hours per year), and 17 percent-21 percent of class time for English (about 135-155 hours per year). Source: Education Bureau, Hong Kong, 2014
202. Director of Education, Education Bureau, Hong Kong, 2000
203. Lin, 2007
204. Education Bureau, Hong Kong, 2015b
205. Education Bureau, Hong Kong, 2015c
206. Education Bureau, Hong Kong, 2015a
207. Education Bureau, Hong Kong, 2015c
208. Education Bureau, Hong Kong, 2015c
209. B. A. Jacob, 2016
210. As of May 1, 2008, 582 out of 729 universities (79.8 percent), 423 out of 597 graduate schools (70.9 percent), and 277 out of 385 junior colleges (71.9 percent) had teacher training courses. National Institute for Educational Policy Research, 2011
211. Interview with Saitama prefecture.
212. National Institute for Educational Policy Research, 2011.
213. Interview with Saitama prefecture.
214. Ministry of Education, Culture, Sports, Science and Technology - Japan, 2015
215. Numano, 2010
216. Ministry of Education, Culture, Sports, Science and Technology - Japan, 2015
217. Ingersoll, 2007
218. The literature also refers to the idea of specialist vs. generalist teachers as departmentalized vs. self-contained
219. This depends heavily on the size of the school. In smaller schools, teachers are more likely to teach all subjects, but in larger schools, teachers may specialize more in their role.
220. Strohl, Schmertzing, Schmertzing, & Hsiao, 2014
221. Chang, Muñoz, & Koshewa, 2008; Gerretson, Bosnick, & Schofield, 2008
222. Strohl et al., 2014; DelViscio & Muffs, 2007
223. Gerretson et al., 2008
224. Fryer, 2016
225. Strohl et al., 2014; Culyer, 1984
226. Culyer, 1984; Chang et al., 2008
227. J. L. Epstein & Dauber, 1991
228. Burke, 1997; Forsten, Grant, Johnson, & Richardson, 1997; Hitz, Somers, & Jenlink, 2007
229. Hanson, 1995; DelViscio & Muffs, 2007
230. Little & Dacus, 1999; Hanson, 1995; Bracey, 1999; Gaustad, 1998; DelViscio & Muffs, 2007
231. Ma, 1999
232. B. Jacob & Rockoff, 2011; Blazar, 2015; Ost, 2014
233. Interview with Education Bureau – November, 2015

234. Interview with Saitama prefecture – November 2015

235. Aldeman & Mitchel, 2016

236. Many studies measure changes in teacher beliefs or confidence, which may or may not actually translate to more effective teaching. For instance, Bursal, 2012 studied the impact of a science methods course for elementary teachers and found that while almost all participants were confident in their science knowledge at the end of the course, 40 percent of the class failed a science misconceptions test. See more discussion in Diamond et al., 2013; Hill, Schilling, & Ball, 2004

237. Kleickmann et al., 2013 Gitomer & Zisk, 2015

238. National Institute of Child Health and Human Development, 2000

239. Interview with professor at HKIEd

240. Interview with professor from Shanghai Normal – January, 2016

241. Zhang et al., 2014

242. Optional elective courses that were math were included as part of the math category, but others were included in the other-education department category.

243. Interviews with professors at the University of Jyväskylä

244. Interview with a professor at the University of Helsinki

245. Correspondence with the University of Jyväskylä, February 2016

246. Correspondence with the University of Helsinki, February 2016

247. Correspondence with the Trade Union of Education in Finland, February 2016

248. Interview with Tokyo Gakugei University in November, 2015

249. Wang, Coleman, Coley, & Phelps, 2003

250. Interview with Naruto University of Education in November, 2015

251. Roberts-Hull et al., 2015

252. Interview with the University of Jyväskylä – November, 2015

253. National Institute for Educational Policy Research, 2011; Wang et al., 2003

254. Roberts-Hull et al., 2015

255. For example, Title II of the Higher Education Act. See Feuer, Floden, Chudowsky, & Ahn, 2013

256. See, for example, Chong, S. & Ho, P., 2009; and Hou, A. Y. C., n.d.

257. See, for example, World Bank, 2007

258. Roberts-Hull et al., 2015

259. Interview with the Finnish Ministry of Education and Culture, November 2015

260. Interview with the Finnish Ministry of Education and Culture, November 2015

261. Interviews with the Trade Union of Education in Finland and Finnish National Board of Education, November 2015

262. Sahlberg, 2014

263. Committee on Professional Development of Teachers and Principals, 2015; for more details: http://cotap.hk/index.php/en/sub-committee-on-initial-teacher-education-scite/membership-list-scite

264. T-dataset and T-bridge are under the overarching project "T-excel@hk", where the 't' stands for the teaching profession.

265. Committee on Professional Development of Teachers and Principals, 2015, p 34-35

266. Committee on Professional Development of Teachers and Principals, 2015, p 46-47

267. Interview with Education Bureau, October 2015
268. Quality Education Fund, 2014
269. Jensen, Hunter, Sonnemann, & Burns, 2012
270. Jensen et al., 2012
271. Tatto, Krajcik, & Pippin, 2013
272. Koster & Dengerink, 2001
273. Lanier & Little, 1986; Howey & Zimpher, 1990; Snoek, Swennen, & van der Klink, 2011; Berry & Driel, 2013
274. Zeichner, 2005
275. Buchberger, Campos, Kallos, & Stephenson, 2000; J. D. Wilson, 1990
276. Chingos & Whitehurst, 2012
277. Rockoff, 2004; Rivkin, Hanushek, & Kain, 2005; D. N. Harris & Sass, 2007
278. Maulana, Helms-Lorenz, & van de Grift, 2015; Papay & Kraft, 2015
279. Ministry of Education, Culture, Sports, Science and Technology - Japan, 2015
280. Teacher Education Ministerial Advisory Group, 2014
281. Rockoff, 2008; Smith & Ingersoll, 2004
282. Smith & Ingersoll, 2004; H. K. Wong, 2004
283. H. K. Wong, 2004
284. 11 days are during school holidays and 8 days are during the regular school year
285. Advisory Committee on Teacher Education and Qualifications, 2009
286. Jensen et al., 2016
287. Freeman & Porter, 1989
288. Agodini et al., 2009; Bhatt & Koedel, 2012
289. Chingos & Whitehurst, 2012
290. Bhatt & Koedel, 2012
291. Chingos & Whitehurst, 2012
292. Deborah Loewenberg Ball & Cohen, 1996
293. MEXT Japan, n.d.
294. Ota, 2000
295. Interview at Ageo Primary School in Saitama, November 2015
296. Interview at Tokyo Gakugei University, November 2015
297. Interview with Sako Primary School in Tokushima, November 2015
298. Interview with National Board of Education, November 2015
299. Interview at teacher training school in Jyvaskyla, November 2015
300. Interview with the University of Helsinki, November 2015
301. TNTP, 2015
302. Toshiya Chichibu & Toshiyuki Kihara, 2013
303. Arani et al., 2010; Interview with Tokyo Gakugei University. Lesson study is conducted at a national and regional level in addition to the regular in-school process, but the focus here is on the smaller-scale lesson study in schools.
304. Stigler & Hiebert, 2009
305. *Lesson Study Research and Practice in Mathematics Education*, 2011
306. Toshiya Chichibu & Toshiyuki Kihara, 2013
307. Stigler & Hiebert, 2009
308. Stigler & Hiebert, 2009
309. Fujii, 2015

310. Darling-Hammond, Wei, Andree, Richardson, & Orphanos, 2009
311. Toshiya Chichibu & Toshiyuki Kihara, 2013
312. Tucker, 2014; Center for Teaching Quality, n.d.
313. Jensen et al., 2012
314. Tan, 2013, p. 187
315. Tan, 2013, pp. 204, 218, Sargent & Hannum, 2009
316. L. N. Wong, 2014, p. 81
317. Jensen et al., 2016
318. Jensen et al., 201
319. Zhang, Ding, & Xu, 2016
320. Jensen et al., 2016
321. Jensen et al., 2016
322. Zhang et al., 2016; Jensen et al., 2016
323. Zhang et al., 2016
324. Numano, 2010
325. Ministry of Education, Culture, Sports, Science and Technology - Japan, 2015
326. Fryer, 2016
327. Aldeman & Mitchel, 2016
328. TNTP, 2015

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