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The organization of the mathematics preparation and development of teachers: a report from the ICMI Study 15

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Abstract This article presents the results of an investigation carried out across 20+ country-regions under the auspices of ICMI Study 15 into the structures, approaches and general characteristics of the mathematics preparation and development of teachers. We use a global framework provided by the larger research literature on teacher education to contextualize the findings. The article provides an analytic perspective on (a) teacher education systems' characteristics including institutional arrangements and regulations; (b) teacher's recruitment, selection, and credentials; (c) teacher education programs' structure and approaches; (d) teacher educators' characteristics; and (e) the structure and content of the curriculum. This article highlights the important differences and similarities across systems that provide mathematics education and development to teachers. This article concludes with a discussion on implications for future empirical research on mathematics teacher education.

Keywords Mathematics preparation · Teacher education systems · Curriculum · Pedagogy · ICMI Study 15 · Teachers

We know little about the organization of the opportunities to learn mathematics and mathematics pedagogy offered to prospective and practising teachers across the world and their relative effectiveness. This lack of cross-national comparative studies on the organization and influence of teacher preparation on teacher learning and subsequent

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practice has often resulted in the development of ad hoc policy with little or no empirical basis (Tatto and Plank 2007). Although national-level studies are fundamental, cross-national comparisons of teacher preparation effects are highly relevant at this moment in the international climate of educational reform. This article presents a cross-national study of the organization of mathematics teacher education. It is framed by the following questions: What are the characteristics of the system and institutions of mathematics teacher preparation? What are teacher education programs' structure and approaches? What is the approach to content in the curriculum? How are teachers recruited and selected to teach at the primary and secondary levels of schooling? What are their credentials?

Globally, teacher education seems to be undergoing a period of dynamic reform. At a system level, political, social, and economic factors exert pressures in nation states, directly influencing teacher's education and work. Current trends in teacher education reform seem to reflect a need for unification as well as diversification in order to compete in a global economy. The response to these pressures is diverse. In some countries, the need to compete in the economy has prompted teacher education programs to add more years and to provide deeper content knowledge, thus relocating teacher preparation in universities. In other countries, the trend has been toward more emphasis on job training. In addition, the emphasis on *performativity* has strengthened trends toward more accountability in teacher education (see Osborn 2007). Research studies on teacher education argue that programs' structure and approach importantly shape opportunities to learn and may influence teachers' knowledge, practice, and, presumably, pupil learning (Hill et al. 2005; Quinn 1997; Vacc and Bright 1999). It is not clear, however, whether structure, approach, other characteristics, or the interaction of all these, have an effect on learning to teach specific subject matter such as mathematics. However, the use of program structure as a *sole* indicator of teacher education quality is problematic, a point extensively argued by Kennedy (1999). Paradoxically, it is program structure that seems to drive teacher education reform worldwide (e.g., Kobayashi 1993; Stuart and Tatto 2000; Hall and Marrett 1996; Kachelhoffer 1995).

Intrinsically linked to structural characteristics, teacher educators can be seen as the most important agents in shaping the teacher education curriculum. For example, the work of Tatto (1998, 1999) indicated that regardless of structure, programs whose faculty held consistent views among themselves and with the curriculum had more success in influencing teacher-learners' views. In many contexts, one of the main tasks of teacher educators is the development and delivery of the curriculum. However, the question on the extent to which the content and organization of the teacher education curriculum and form of delivery have an effect on teachers' mathematics knowledge is addressed in only few studies in the international literature (e.g., Fuson et al. 1997). Another important aspect of teacher preparation systems concerns the characteristics of those who enter the profession. Selection policies requiring specific levels of subject matter knowledge may increase the quality of future teachers as per studies documenting the impact of mathematical education of prospective and practising teachers on teaching and student achievement (Monk 1994). Nevertheless, anchoring selection policy on individuals' qualifications presents enormous definition problems because levels of education attained, as expressed in credentials, is subject to variability in the depth and quality of the education received within and across countries (Boswell 1995; Fuller and Clarke 1994).

This article uses a system and institution framework to explore diverse aspects characterizing the mathematics preparation and development of teachers cross-nationally.

System and institution framework

From a system perspective, teacher education evolves within and interacts with social, cultural, economic, and political contexts. The development of teacher preparation policy shapes the institutions and goals for teachers and their role. From an institutional perspective, the education of mathematics teachers is dependent on the occurrence of a number of interconnected events which are in turn closely related with the life cycle of the teaching profession: entry to teacher education signals the beginning of teachers' careers; once in teacher education programs, individual characteristics interact with the opportunities to learn provided to teachers; these opportunities to learn are influenced by cultural and social assumptions of what it takes to become a good mathematics teacher. The outcomes of teacher education are in turn reflected on actual teachers' knowledge and practices refined during practicum or equivalent experiences. Recruitment and selection processes and individual expectations among those choosing to become generalist or specialist mathematics teachers, as well as the job market, culminate in the placement of teachers in the classroom. Once in the classroom, the knowledge acquired during teacher education is expected to transfer into knowledge *for* teaching and, presumably, on improved pupil learning. Such knowledge may further improve as teachers continue to develop into mature professionals. How well this sequence occurs depends on the availability of resources (institutional and individual) that provide teachers with opportunities to learn as well as in attracting, placing, and maintaining those qualified teachers in classrooms. This framework is based on empirical research and extensive reviews of the comparative research literature on teacher preparation (Tatto 2008). In this study, some aspects of this framework were used to both organize the findings and to point to future research directions.

Research process

The data for this study were collected as part of the 15th conference of the International Commission on Mathematical Instruction (ICMI-15) held in Sao Paulo, Brazil, May 2005, with a focus on the Professional Education and Development of Teachers of Mathematics. The premise of ICMI-15 was that "the education and continued development of teachers is fundamental to students' opportunities to learn mathematics and that an inquiry focussed on mathematics teacher education practice and policy around the world can provide insights useful to examining and strengthening all systems […] locally and globally" (Ball and Even 2004, p. 282; Even and Ball 2009). The data consisted of findings of research reports submitted to Strand I of ICMI-15, which dealt with the organization of mathematics teacher education. These studies explored the initial and continuing education of teachers of mathematics at all levels, from those who teach in early schooling, to those who teach at the secondary school level. They included questions on the structure, recruitment, retention, curriculum, history, change, and current challenges in teacher preparation, as well as information on the early years of teaching. The detailed questions can be found in Ball and Even (2004, pp. 283–285).

Most of the data represent the organization of teacher education at national levels. When this is not the case (e.g., in the United States and Canada), we refer to country-regions. Twenty-one reports were considered complete and included in this study. The countries (regions) represented in these reports are: Australia, Botswana, Brazil, Canada (Quebec), Canada (Western Ontario), China (South-Guangzhou), Czech Republic, Denmark,

England, France, Germany, Israel, Italy, Portugal, USA (California, Michigan, Minnesota, Ohio, Virginia), South Africa, Spain, Sweden, Uganda, Turkey, and Venezuela. Though questions regarding the structure and organization of mathematics teacher education may seem simple, collecting these data can be quite challenging, as this kind of information is not readily available at the "system" level. Often the information available in a given country is too general to fit the objectives of this task (e.g., data on teacher education is usually at the *general* level and, information on mathematics or other subject-specific data is hard to find readily available). Thus, this group of countries that provided data should be seen as a self-selected group who agreed to undertake a fact-finding mission to answer the questions posed by the ICMI 15 organizers.[1]

Analysis of the 21 reports focussed on coding, identifying, and comparing: (i) the overall organization of the system of teacher preparation in a given country setting, (ii) the structure of teacher education programs including those who teach in them, (iii) the content of the curriculum, and (iv) issues dealing with teachers' recruitment and selection, as well as the credentials obtained. In the analysis, "primary" was defined as students of ages 5–11; "middle" as ages 11–14, and "secondary" as ages 14 and older. However, there were variations to this classification in some countries (e.g., in the United States, "primary" is ages 6–11 and "secondary," divided into lower and upper levels, is ages 11 or 12 through 18 or 19).

Characteristics of the system and institutions of mathematics teacher preparation

The findings illustrate diverse trends among the participating countries/regions in terms of the institutional arrangements and regulatory systems.

Institutional arrangements

What institutions provide mathematics preparation for teachers? Among the 21 countries (regions), three-fourths reported the universities as the major context for preservice teacher education. This is the case, for all school levels, for Australia, Brazil, Canada (Western Ontario), Canada (Quebec), Czech Republic, England, France, Germany, Italy, South Africa, Spain, the USA (with some exceptions), and Venezuela. For Denmark, Portugal, Sweden, Turkey, and Uganda, this is true only for the secondary school level. Whereas in some countries, university education for teachers has been a long-standing tradition such as Germany, others, such as South Africa, have just recently moved in this direction. In other countries, including Denmark, France and Venezuela, teacher education is located in national Teacher Colleges or it represents a combination of both, education in universities and in teacher colleges. In China, initial education occurs in teacher colleges while in-service preparation is offered in other tertiary institutions. England's teacher education presents the most diversity as it is located both in universities and in schools and it also permits a number of variations including an examination-only option. Uganda covers the most range including education in universities, primary and national teacher colleges, and schools; in-service education is offered via the distance education model. In Israel pre-service education for primary school teachers is done in teachers colleges, whereas pre-service education for mathematics high school teachers is done in universities. Israel's in-service is provided in a variety of ways: through regional teachers' centers associated with

[1] Details on the contributors to this article can be found on the reference section in an earlier summary report, see Tatto et al. (2009).

the Ministry of Education and through two national teachers' centers affiliated with universities for primary and for high school mathematics teachers; these centers include a distance education modality as well.

These findings suggest that there is great diversity in the organization of teacher preparation and development with two dominant trends. One trend is the placement of teacher preparation in higher education institutions presumably in pursuance of more intensive training in mathematics as a discipline; the other trend places teacher preparation in teachers colleges in pursuit of training in pedagogy.

Regulatory systems

How regulated are the teacher education programs in different countries? This was estimated through the existence of regulation, standards or an overseeing body at the national or local levels or both. Countries/regions reporting national level regulation were Australia (e.g., through the Institute of Teachers, and the Board of Teacher Registration), Brazil (with the national Council of Education), China, the Czech Republic (Universities/Faculties propose their programs but these must be accredited by the Ministry of Education), England, France, Mexico (through the Ministry of Education and the Teachers' Union), Spain (through the Law of Educational Reform), Sweden (through the government and parliament), Turkey (through the Higher Education Council and National Ministry of Education), and Venezuela. Notably are England and France as examples of a strong regulatory centralized system. Localized control is prevalent in Canada (Quebec), Denmark, Germany (through regulations within the 16 states), Israel, Italy, Portugal, South Africa, and Uganda. In the USA, there currently exists a hybrid mechanism of local and, increasingly, national control (e.g., state level standards).

In sum, whether at the national or local level, there seems to be a trend toward increased accountability and regulation of teacher education programs and increasingly outcomes.

Teacher education programs' structure and approaches

Preservice and in-service structures

Although the survey shows great variability among the options offered future teachers, overall, preservice teacher education can be understood as of two kinds: concurrent (bringing together general education, pedagogy, and teaching practice); or consecutive (general education occurs independently of—and usually preceding—teacher education and includes teaching practice). In-service preparation presents more variability including graduate studies in universities, short ad hoc courses provided by a related teacher-education authority, distance education courses and even examinations—only alternatives.

The preservice *concurrent preparation* modality is defined as the joint occurrence of general education and professional education in a single program. In addition, this modality includes varying periods of field-based practice. In the case of the ICMI-15 survey, programs included preparation on the mathematics content and pedagogy, and varied lengths of field experience or practice. The length of all these periods is quite variable, and for the most part, the period for both mathematics and pedagogy preparation range from 3 to 6 years, and the period of practice varies from 80 days to a year. The preservice *consecutive preparation* modality consists of an independent period of general education and a separate period of teacher preparation to which a period of practice may be

Table 1 Country and regions that have teacher education programs in a concurrent modality

Country/Region	General education and teacher education	Practice[a]
Australia	4 years	80 days
Brazil	4 years	100 days (800 h)
Canada (Quebec)	4 years	87.5 days (700 h)
Canada (U of W. Ontario)	Primary: mathematics—25 h (9 in online modules) and 18 h elective	
China (PR)	Primary 3 years	
Czech Republic	Primary 4 years; secondary 5 years	
Denmark	4 years	35 days (7 weeks)
France	4 years or 3 years undergraduate, plus 1 year graduate courses	1 year
Israel	Primary: 3 years Secondary: 4 years	Additional time, not specified
Italy	Primary: 4 years	25 days (200 h)
Portugal	Primary: 4 or 4.5 years Secondary: 4.5 or 5 years	
South Africa	4 years	60–120 days (12 or 24 weeks)
Spain	Primary: 3 years Secondary: 5 or 4 years, plus 1 month of psychology and didactics of mathematics courses	
Sweden	K-5: 3.5 years 6–12 grades: 4.5 years	100 days (20 weeks)
Turkey	Primary: 5 years; secondary: 5.5 years	
Uganda	Primary: 2 years Secondary: 2 years	60 days (12 weeks)—primary 30 days (6 weeks)—secondary
USA	4 or 5 years	1 year
Venezuela	Primary and secondary: 5 years	22.5 days (180 h)

[a] For purposes of comparison, we have converted the original times given in hours, days, and weeks to one metric: days assuming a day equals 8 h of practice; however, the original estimate given in the country reports is shown in parenthesis. Estimates given in a *year* metric stay the same

attached. In the ICMI-15 reports, the range of general education varies from 2 to 5 years of general education (e.g., in mathematics) and from 1 to 4 years of teacher preparation. Periods of practice vary from 45 days to 2 years in schools. In-service preparation for experienced teachers was reported in China (a 1-year modality; and an assessment-only modality which takes into account years of experience and the result of an examination in the subject (s) of interest); and in Uganda (where there is a 3-year modality, plus 8 weeks of practice).

These findings show that the structure and approaches followed in teacher preparation and development across these settings is quite diverse. The most variation occurs on the level of mathematics knowledge teachers acquire before they begin to teach, and on the length of time given to practice teaching before they are declared ready to take on a full-time teaching position. While this variability provides a rich opportunity for study, it may also indicate the lack of a coherent understanding of effective approaches to better prepare teachers to teach mathematics. In-service approaches show even more variation and seem

Table 2 Country and regions that have teacher education programs in a consecutive modality

Country/ regions	General education	Teacher education	Practice (see Table 1)
Australia	Secondary: 3 years	1 year	45–55 days
China (PR)	Secondary: 4 years	3 years	
England	Postgraduate: 4 years	1 year full-time or 2 years part-time	Not indicated
	"Fast Track": 4 years	4 years	Some practice
	"Undergraduate route": 4 years	4 years full time	Not indicated
	"RTP" 2 years	n.a.	2 years in school
		"Employment based": 4 years	60 days to 1 year (3 months to 1 year in school)
France	Secondary: 3 years	2 years	180 days (9 months)
Germany	Primary: 3 years Secondary: 5 years	Primary/Secondary: 2 years	Several years in-service
Israel	Secondary: 3 years	2 years	
Italy	Secondary: 5 years	2 years	
South Africa	4 years	1 year	30 days (6 weeks)
Spain	5 years	600 h of teacher education which include practicum and student teaching	
Uganda	Secondary: 3 years	12 weeks	
USA	Overall: 4 years	1 or 2 years	Varying periods for practice
	Alternative routes: 4 years	Varying monthly periods	

to be used as ad hoc policy tools to compensate for the perceived inadequacies (if any) of preservice approaches. Tables 1 and 2 below show these contrasts.

Who are the teacher educators?

The survey found that those teaching teachers are differentiated according to the institutional department and discipline they teach. Thus, for the most part, mathematicians teach mathematics courses (e.g., Australia, Brazil, Canada (French), China, Czech Republic, England, France, Germany, Israel, Spain, Uganda, USA, and Venezuela). In some cases, these courses are taught by mathematics educators. For the most part, pedagogy courses are taught by educators or in some cases (such as Israel) mathematics educators, who may have background in psychology, sociology or philosophy, or may be experienced teachers. Practicum is for the most part supervised by practising teachers and teacher educators. These findings align with the emphasis placed on the level of mathematics knowledge deemed necessary for teachers to have.

An unresolved question in this area is whether the mathematics courses taught by mathematicians help teachers acquire the mathematics understand they will need to teach; or whether this understanding is better conveyed by mathematics educators, and by practising teachers.

Approach to content in the teacher education curriculum

The survey also collected information on the overall curricular structure of teacher education including notions about sequence and delivery. What content goes into the teacher education curriculum? Similar to our findings in other areas of teacher education, it should not be surprising to find a great deal of variety in the curriculum offered to teachers within and across countries. However, this is an area where the field suffers from definitional problems and where labels may mean a variety of things (e.g., what is understood by pedagogy and what should be the content included in a pedagogy course). As a beginning point, and recognizing that these still remain for the most part theoretical propositions, we nevertheless used three of Shulman's (1987) five dimensions of *teachers' professional knowledge* (content knowledge, pedagogical content knowledge, pedagogy) as a framework for this section.

Table 3 Emphasis on mathematics content, mathematics pedagogy, and pedagogy knowledge[a]

	Low emphasis		High emphasis	
	Primary	Secondary	Primary	Secondary
Mathematics content knowledge				
Specialists	England	Australia, England	France, Israel	Czech Republic,[b] France, Uganda, Israel, Italy, Portugal, Spain, South Africa,[c] Sweden, USA
Generalists	Australia, Canada (Ontario), Israel, Italy, Portugal, South Africa, Uganda, USA, Venezuela	Denmark	Czech Republic, Germany, Sweden, Turkey	Canada (Quebec), Germany, Turkey, USA, Venezuela, Brazil
Pedagogical content knowledge				
	Canada (Ontario), Portugal, South Africa, USA, Venezuela	France, South Africa, Spain, USA, Venezuela	Brazil, Czech Republic, France, Germany, Israel, Italy, Sweden, Turkey, USA	Australia, Brazil, Canada (Quebec), Czech Republic, Denmark, England, France, Germany, Israel, Italy, Portugal, Sweden, Turkey, USA
Pedagogy				
	Turkey, USA	Canada (Quebec), France, South Africa, Spain, Turkey, USA	Brazil, Canada (Ontario), Czech Republic, England, France, Germany, Israel, Italy, Portugal, South Africa, Sweden, USA, Venezuela	Australia, Brazil, Canada (Ontario), Czech Republic, Denmark, England, Germany, Israel, Italy, Portugal, Sweden, USA, Venezuela

[a] Indicates emphasis in the teacher preparation curriculum and does not imply lack of strong mathematics preparation among candidates previous to teacher preparation which they may acquire if they follow a consecutive route (e.g., attended 4 years of general education in a separate institution)

[b] In the Check Republic, secondary teachers have a 2-subject qualification

[c] In South Africa, two models of teacher training are implemented. The emphasis on the individual types of knowledge is not the same in both models

The information gathered from the survey is shown in Table 3 and illustrates a range of emphasis in the opportunities to learn mathematics content across settings with striking differences between the primary and secondary levels. Most primary teachers are educated as generalists and most of the preparation they receive places low emphasis on mathematics content (as per the proportion of time dedicated to mathematics courses as part of their overall program). For secondary teachers, there seems to be a stronger emphasis in specialization on the subject with a higher emphasis on mathematics content (as per the proportion of time dedicated to mathematics courses as part of their overall program).

The lack of emphasis on mathematics in some teacher education programs may be attenuated by programs, which as part of their entry selection strategy, require a high level of mathematics knowledge or by those programs that are consecutive thus assuring that future teachers bring with them a high level of mathematics knowledge into their teacher preparation. Nevertheless, in some cases, teachers graduate from programs with little or no knowledge of mathematics. In the case of secondary teachers, this presents yet another possible troubling trend regarding the level of mathematics knowledge teachers may hold. This trend is found globally (Stuart and Tatto 2000; Tatto 2007).

The survey revealed (with some exceptions) that those who design teacher education programs give a fair degree of emphasis to "pedagogical content knowledge" in mathematics. The findings shown in Table 3, however, should be taken with caution as this term is used differently in different settings (e.g., didactics seems to be a term that indicates the intersection of content knowledge and pedagogy though the balance is less clear). The trend shows a higher emphasis given to this knowledge in the education of secondary teachers, while a possible troubling trend that would need to be explored further is the lack of data reported on the emphasis given to pedagogical content knowledge in the education of primary teachers. As the survey shows, general pedagogy is a major if not the only emphasis in a large number of teacher preparation programs. In contrast with the information on content pedagogy, the report on the emphasis of pedagogy is more consistent. Table 3 shows a high level of emphasis given to this knowledge in the preparation of primary teachers, and a possible troubling trend toward low emphasis in the preparation of secondary teachers. The following countries/regions declared extensive field experience in their teacher preparation program (e.g., more than 6 months): Brazil, Canada (Quebec), Denmark, England, France, Germany, Italy, Portugal (secondary), South Africa (primary), Turkey, USA, and Venezuela. Countries with limited field experience (less than 6 months) were Australia, Spain, Portugal, Uganda, USA, South Africa (secondary), and Sweden.

The notion that future teachers need to have the opportunity to practice what they learn seems to be widely recognized in the field of teacher education. The survey showed that practically every program makes allowances for some kind of field experience thus presumably strengthening the links between theory and practice. This presumption, however, is still subject to empirical investigation.

Recruitment and selection of mathematics teachers

Who enters teaching? The survey showed that for most of the countries/regions, the entry level to the profession occurs after secondary education, with exception of secondary teachers in Germany, England, and Italy where teaching is a graduate, and by definition post-university, profession. Few regions reported clear entry level selectivity criteria based

Table 4 Credentials awarded prospective mathematics teachers

Credentials	Primary	Secondary
First stage of tertiary education (postsecondary education such as 2 years college or beyond but not research qualification)	Canada (UWO), China, Germany, Israel, Italy, South Africa, Sweden, Uganda, Venezuela, USA (some with grad credits)	Australia, Brazil, Canada (Quebec), China, Denmark, France, Germany, Uganda, South Africa, Spain, Sweden, Venezuela, USA (some grad credits)
Second stage of tertiary education (includes research qualification) advanced study and original research and are not based on course-work only	Czech Republic, England, Portugal	Australia, Czech Republic, England, Israel (required but not enforced), Italy, Portugal, Uganda

on examinations or mathematics requirements such as in the Czech Republic ("Maturita" for upper secondary), England, France ("CAPES" + 3 examinations in academic mathematics for school assignation and dissertation), and Germany (first and second State examinations at end of university-based phase I and school-based phase II, respectively). In Brazil, there is an additional examination in mathematics and another subject, which is required to obtain upper secondary qualification. In other countries such as Spain, there is a competitive state examination for school placement in public schools and a mathematics requirement for secondary school teachers. In Uganda, the selectivity criteria for future primary teachers include "O level" examinations with a pass in mathematics and English language; while for future secondary teachers, the requirement is an A-level examination with two principal passes in mathematics and relevant subjects. In the USA, the selectivity criteria vary across states. Entrance to teacher education may be determined by entrance requirements set at the university level which in some cases take into account results on national standardized examinations. In addition, a large number of states have instituted teacher examinations, which must be taken before teachers can become certified. In Venezuela, selectivity includes entrance examinations but as in other countries, most future teachers are asked to fulfill a mathematics requirement.

Credentials awarded prospective mathematics teachers

The survey results signal a growing trend to award credentials to teachers at least at the first stage of tertiary education. In some cases, mathematics teachers teaching higher grade levels hold credentials at the second level of tertiary education. As Table 4 shows, most primary and secondary teachers reach the first stage of tertiary education. Others obtain the second stage of tertiary education as some countries seem to offer or even require a full Master's qualification before people can enter the profession.

These findings should be interpreted with caution, however. As previously discussed, as important as the credential is, it provides limited information regarding the level of knowledge attained by teachers and whether such knowledge provides the basis for effective teaching. Understanding what is in a credential amounts to looking into the "black box" of teacher education and to the quality and kind of opportunities to learn as they support teacher knowledge.

Significance and implications of ICMI Study 15

Although this study was designed as an exploratory attempt at asking key questions related to mathematics teacher preparation and the results are of a preliminary nature, its contribution to the field is significant in the following ways.

It signals the importance of systematically collecting (at the national, local and institutional levels) mathematics-specific information on teacher preparation for those countries/regions that do not do so already—general information is meaningless for policy when, for instance, the goal is to understand how to develop effective programs to support teachers' mathematics learning.

The mathematics-specific information presented here provides indicators of larger and important trends in the field. For instance the examination of the system for the mathematics preparation of teachers indicates that although a larger proportion of preservice programs are located in the universities, a global market economy seems to be pushing teacher preparation out of universities and into the schools where future teachers may not find the expertise to further their mathematics knowledge. Although an overall pattern seems to be for future and practising teachers to follow a combination of general and professional preparation with varying periods of practice, we still lack information regarding how opportunities to learn are organized during those years, and the impact that these diverse opportunities have on mathematics learning and on learning to teach mathematics. Trends toward accountability and standards development world-wide can be seen reflected in these reports suggesting important changes in the work of teacher educators and on the curriculum they teach; while also placing the teacher preparation system under more centralized (state) control.

Although the research literature seems to increasingly point to the importance of mastering mathematics among those who teach it, our preliminary inquiry makes evident a worrisome trend especially among primary teachers who find themselves in programs that prepare them as "generalists" and where the curricular emphasis in mathematics and mathematics pedagogy is seen as "low". The lack of mathematics emphasis among secondary teachers, albeit in a lower number of countries, is an important finding. This deficit, however, seems to be balanced by a higher exposure to mathematics pedagogy.

While this study is a beginning, there is a need to design policy-oriented studies according to a typology of comparative differences within and across regions that can give better insights on the teacher education-teaching practice-pupil learning continuum taking into account contextual differences (Lerman and Tsatsaroni 2005). Such studies need to define constructs and indicators and develop methods and sampling strategies to allow for more rigorous investigation of teacher preparation systems. Specifically, there is a need for comparative studies on the characteristics of teacher education systems and the paths through which they are likely to influence teacher knowledge, teacher practice and pupil learning. This is especially important in the development of empirically-based theories of teacher preparation and the implications for teaching quality. In conclusion, the use of a comparative framework to explore issues of effectiveness of policies directed at reforming and regulating preservice and in-service teacher preparation would help educators and policy makers understand not only what characteristics of different education systems seem to have an important impact on subject-specific teacher education, teaching practice and pupil learning but also what are the systemic conditions that make it possible. Understanding these conditions is essential in conceptualizing viable policy to improve the mathematics preparation of teachers.

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