

revista de **EDUCACIÓN**

Nº 372 ABRIL-JUNIO 2016



¿Hay un vacío en la formación inicial del profesorado de matemáticas de Secundaria en España respecto a otros países?

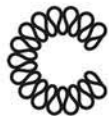
Is there a gap in initial secondary mathematics teacher education in Spain compared to other countries?

Laura Muñiz-Rodríguez
Pedro Alonso Velázquez
Luis J. Rodríguez Muñiz
Martín Valcke



revista de
eEDUCACIÓN

Nº 372 ABRIL-JUNIO 2016



IV CENTENARIO
CERVANTES

revista de
EDUCACIÓN

Nº 372 Abril-Junio 2016

Revista trimestral

Fecha de inicio: 1952



MINISTERIO DE EDUCACIÓN, CULTURA Y DEPORTE

SECRETARÍA DE ESTADO DE EDUCACIÓN, FORMACIÓN PROFESIONAL Y UNIVERSIDADES

Instituto Nacional de Evaluación Educativa
C/ San Fernando del Jarama, 14
28002 Madrid
Teléfono (+34) 91 745 92 39
revista@mece.es

Edita
© SECRETARÍA GENERAL TÉCNICA
Subdirección General de Documentación y Publicaciones.

Catálogo de publicaciones del Ministerio: mece.gob.es
Catálogo general de publicaciones oficiales: publicacionesoficiales.boe.es

Edición: 2016
NIPO línea: 030-15-016-X
NIPO ibd: 030-15-017-5
ISSN línea: 1988-592X 0034-8082
ISSN papel: 0034-8082
Depósito Legal: M.57/1958

Diseño de la portada: Dinarte S.L.
Maqueta: Solana e hijos, Artes Gráficas S.A.U.

Is there a gap in initial secondary mathematics teacher education in Spain compared to other countries?

¿Hay un vacío en la formación inicial del profesorado de matemáticas de Secundaria en España respecto a otros países?

DOI: 10.4438/1988-592X-RE-2015-372-317

Laura Muñiz-Rodríguez

Pedro Alonso Velázquez

Luis J. Rodríguez Muñiz

Universidad de Oviedo

Martin Valcke

Universitet Gent

Abstract

Initial teacher education is a key factor in the teaching and learning process. Previous studies on educational policies evidence some deficiencies in the quality of teacher training programs in Spain, both in primary education and secondary education. In 2008, Spain participated, along with 16 other countries, in the Teacher Education and Development Study in Mathematics (TEDS-M), an international comparative study which examined how different countries prepared their prospective teachers to teach mathematics in primary and lower-secondary school. The Spanish participation in the study was limited to future primary teachers; but, what is the situation of initial education for future secondary mathematics teachers in Spain? In this paper we present an analysis of initial training programs for future mathematics teachers in secondary

⁽¹⁾ This work has been partially supported by Campus of International Excellence of University of Oviedo.

education in Spain. First, we study the main characteristics of initial teacher training programs in other countries: organization, structure, duration, access requirements, and professional standards. Next, we analyzed the Spanish situation, starting with a brief historical review of the previous model, and continuing with a detailed description of the current approach. The results show clear differences when comparing Spain with other countries, and indicate the need of introducing measures in order to overcome the current deficiencies of teacher training programs and contribute to the improvement of its quality.

Key words: initial teacher education, teacher training programs, secondary mathematics education, prospective mathematics teachers, secondary mathematics teacher competences.

Resumen

La formación inicial del profesorado es un factor clave en el proceso de enseñanza-aprendizaje. Estudios previos sobre políticas educativas señalan un problema de calidad en los programas de formación inicial docente en España, tanto a nivel de Educación Primaria como de Educación Secundaria. En 2008, España participó, junto con otros 16 países, en el Teacher Education and Development Study in Mathematics (TEDS-M), primer estudio internacional comparativo sobre el conocimiento adquirido por los futuros profesores de matemáticas en Educación Primaria y Educación Secundaria obligatoria al acabar su formación inicial. La participación española en el estudio quedó limitada a futuros maestros; pero ¿cuál es la situación de la formación inicial para futuros profesores de matemáticas en Educación Secundaria en España? En este artículo presentamos un análisis de los programas de formación inicial para futuros profesores de matemáticas en Educación Secundaria en España. En primer lugar, estudiamos las principales características de la formación inicial docente en otros países: organización y estructura de las enseñanzas, duración, requisitos de acceso, estándares profesionales, entre otras. A continuación, analizamos la situación española, comenzando con una breve reseña histórica del modelo anterior, y continuando con una descripción detallada del enfoque actual. Los resultados demuestran claras diferencias cuando comparamos el caso de España con otros países, e indican la necesidad de adoptar medidas que permitan suplir las principales carencias de estos programas y contribuyan a la mejora de su calidad.

Palabras clave: formación inicial docente, programas de formación inicial, educación matemática secundaria, futuros profesores de matemáticas, competencias del profesor de matemáticas en educación secundaria.

Introduction

All over the world, there is a growing concern about mathematics education. At the same time, initial teacher education has been questioned due to the results from the national and international assessments such as PISA (Program for International Student Assessment), TIMSS (Trends in Mathematics and Science Student) or PIRLS (Progress in International Reading Literacy Study). In particular, initial education for secondary mathematics teachers in Spain is a matter of concern to educational authorities and policy-makers. This focus on teacher education could arise because of evidence suggesting that Spanish teachers lack essential knowledge for teaching mathematics due to the low quality of initial education programs for secondary mathematics teachers.

We can illustrate this checking that there is a lack of national teaching standards and general guidelines determining what specific competences, skills, contents, and assessments procedures future mathematics teachers should acquire. While some European countries, such as United Kingdom or Germany, provide central level regulations, recommendations and guidelines for initial teacher education programs, Spanish universities are very autonomous in determining the content of their mathematics teacher education programs.

Another thorny problem is that each institution is allowed to establish specific restrictions and entry requirements candidates should fulfill in order to enter to a specific education master program, as it is explained further ahead in the text. Consequently, future mathematics teachers' content knowledge seems to be varied, heterogeneous, and badly structured.

Available research evidence and theoretical frameworks give clear directions when studying teacher education and its position within an educational system. For instance, some studies in the European framework highlight that initial teacher education has significant influence on the learning process, emphasizing the close relation between the quality of students learning and the quality of teacher education based on initial and continuous education programs. On the other hand, meta-analysis studies point at the weak relationship between initial teacher education and the quality of student learning.

Furthermore, absence of practical preparation in teacher education could have important consequences, such as novice teachers lacking the

coping skills necessary to fulfill their teaching roles, often resulting in a theory-practice shock, and/or high rates of attrition during the first years of teaching. In this sense, prospective secondary teachers in Spain complain about the missing link between theory and practice.

The main goal of this article is to carry out a critical analysis of initial education programs for secondary mathematics teachers based on an international comparison in order to identify its principal strengths and weaknesses and suggest adequate measures to ensure a high quality teacher education system. For our purpose, we first draw an international comparison of teacher training approaches for prospective secondary mathematics teachers, focused on organizational and structural features such as duration, structure, level of the degree awarded at the completion of the teacher training program, requirements students should fulfill in order to enter into the program, and existence of a professional competency framework for student teachers. This international perspective is next used to analyze the Spanish context and identify crucial differences that can arise important consequences in the Spanish teacher education system quality. Finally, we discuss possible prospective actions based on the results obtained from the analysis.

An international view of initial education programs for secondary teachers

In many countries, in order to become a teacher, candidates are required to have successfully finalized an initial teacher education program. However, teacher education programs vary considerably across nations. In this section, in order to identify how countries around the world prepare teachers to teach mathematics in secondary² school, we present some descriptive data. The analysis is based on comparisons of 14 countries: Chile, Finland, France, Germany, Israel, Italy, Japan, Korea Republic, Norway, Poland, Spain, Turkey, United Kingdom and United States. We opted for these countries since they involve diverse and representative educational models in the international framework.

⁽²⁾ From now on, according to the International Standard Classification of Education ISCED 2011 (UNESCO, 2012), the term *secondary* will refer to ISCED 2&3.

Characteristics of initial education programs for secondary teachers

After analyzing international comparative studies based on initial teacher education, we noticed broad differences in key structural and organizational characteristics of initial education programs for secondary teachers in public institutions in the set of considered countries, such as duration, organization, level of the degree awarded and existence of entry requirements to access into initial education programs.

Initial education programs are typically organized according to two well-distinguished structures:

- The concurrent model, in which general education and professional education occurs simultaneously in a single program.
- The consecutive model, in which students pursue their subject studies first and after take a professional course in education which provides them with the theoretical and practical competences and skills needed to succeed as a teacher.

In the concurrent model students are involved in specific teacher education right from the start of their studies, whereas in the consecutive model this occurs after their bachelor degree (see Table I). Although the literature points out that concurrent models allow prospective teachers to develop a true professional identity as a teacher since the beginning of their initial education (Esteve, 2006), there are no significant differences between both models and the results of students learning (Valle & Manso, 2011).

As shown in Table II, the organization of initial teacher education programs vary from country to country. While in Finland, Japan, Poland and Turkey concurrent model is predominant, in France, Germany, Italy and Spain teacher training follows a consecutive model. At the same time, both concurrent and consecutive models coexist in some nations such as Chile, Israel, Korea Republic, Norway, United Kingdom and United States. In particular, in Germany initial teacher education programs are differently organized among the different states.

TABLE I. Advantages and disadvantages of concurrent and consecutive programs

Model	Advantages	Disadvantages
Concurrent	More integrated learning experience	Little flexibility in entering the teaching profession
Consecutive	More flexible entry into the teaching profession	Weaker pedagogical knowledge
	Teachers have a strong subject - matter knowledge	Fragmented learning process

Source: Adapted from Musset, 2010.

TABLE II. Organization of initial teacher education programs for secondary teachers

Organization	Countries
Concurrent	Finland, Japan, Poland, Turkey
Consecutive	France, Germany, Italy, Spain
Concurrent and consecutive	Chile, Israel, Korea Republic, Norway, United Kingdom, United States

Source: Own elaboration based on data from OECD, 2014; Tatto *et al.*, 2012.

The duration of initial education programs for secondary teachers ranges from 4 years in Israel, Japan, Korea Republic and United States to between 6 and 6.5 years in Germany, Italy and Norway. Concurrent model commonly lasts 4 years, while for consecutive model the first phase typically lasts between 3 or 4 years and the second phase 1 or 2 years. Furthermore, a teaching internship is mandatory in most countries. However, the required duration vary significantly. For instance, in Israel, Japan, Korea Republic, Spain and Turkey practicum lasts between 20 and

60 days, as opposed to 120 days in United Kingdom, and at least 282 days in Germany.

Not all countries impose educational requirements for entry into initial teacher education programs. Besides that, selective criteria to enter educational training programs are used. For instance, in some countries candidates are selected based on their previous training grade-point average, while in others selection is based on an interview or a competitive examination.

Finally, the level of the degree awarded after completing a teacher training program also differ across countries, mainly depending on its length. In this way, master degree diplomas are obtained after at least five years of tertiary education (see Table III).

TABLE III. Level of the degree awarded at the completion of a teacher training program

Level of the degree awarded	Countries
Bachelor	Chile, Israel, Japan, Korea Republic, Norway, Poland, Turkey, United Kingdom, United States
Master	Finland, France, Germany, Italy, Poland, Spain, United Kingdom

Source: Own elaboration based on data from OECD, 2014; Tatto *et al.*, 2012.

International standards for secondary mathematics teachers

Teacher education is generally guided by national standards which specify what professional qualifications are expected from a student teacher at the end of initial education program. However, in many countries there is a lack of such teaching standards, and institutions even have a high level of autonomy in developing detailed competence requirements in teacher education programs. In this way, while some countries put forward very clear and detailed standards, in others very general guidelines are provided by educational ministries; some examples are:

- detailed lists of specific competences linked to professional

standards and professional development; e.g. United Kingdom, United States.

- specific standards to guide the assessment of newly trained teachers in line with the competences to be developed during the education program; e.g. Chile, Germany.
- framework of teacher competences expected on completion for preparing both pre-service and in-service teachers; e.g. Turkey.
- general standards for teachers defining the assessment of trainee teachers; e.g. Israel, Japan, Korea Republic.
- curricula for initial teacher education mentioning teachers competences required for initial teacher education; e.g. Finland, Poland, Spain

Considering those countries with a deeper development in teacher standards as well as specific standards for secondary mathematics teachers established by international associations –such as NCTM (National Council of Teacher of Mathematics) or AAMT (Australian Association of Mathematics Teachers)– we can define a common list of core standards for secondary mathematics teachers in the international framework (see Table IV).

Besides, in a few countries such as United Kingdom or Korea Republic, a comprehensive list of benchmarks has been established in order to determine to what extent teacher standards should be attained. Therefore benchmarks specify the range of skills, abilities, knowledge, understanding and values prospective teachers should developed, and in regards to which they might be assessed. This aims to ensure a high quality teacher education system, since they clearly define initial teacher education programs, acting as a template for a balance assessment. However, this is not a common feature in the international framework.

TABLE IV. Core standards for secondary mathematics teachers

Standard	Description
1. Mathematical content knowledge	Know and understand mathematical concepts, ideas, theories and procedures according to different mathematical branches such as number, algebra, geometry, trigonometry, statistics, probability, calculus, and discrete mathematics.
2. Mathematical pedagogical knowledge	Comprehend how students learn mathematics, and understand how mathematics should be represented, communicated, and connected with other subject areas.
3. Teaching and learning theories and processes	Select and employ a wide variety of strategies and materials for teaching and learning mathematics appropriate to students' age, needs and backgrounds.
4. Classroom management	Manage students' behavior effectively to ensure a good and safe learning environment, motivating and promoting student's progress and outcomes.
5. Lesson planning	Plan well-structured lessons, creating spiral curricula based on students' backgrounds and prior mathematical knowledge, and employing instructional strategies that enable students to engage in real-world tasks, working individually or in groups.
6. Assessment and mentoring	Use a range of assessment strategies to provide constructive feedback to students, parents and school authorities, with respect to skills, mathematical knowledge, processes and attitudes, and to plan appropriate future learning experiences.
7. Developmental psychology	Understand how children and adolescents learn and develop, providing learning experiences that are developmentally appropriate and challenging for students' age.
8. Inclusion and diversity	Have a clear understanding of the needs of all pupils, including those with special needs, those of high ability, those with disabilities, and be able to adapt teaching approaches to address student diversity.
9. Technology knowledge	Exhibit knowledge and skills in technology systems as an essential tool for teaching and learning mathematics. Design and develop learning experiences and assessments using digital tools.
10. Communication skills	Understand and use effective verbal, nonverbal, and written communication techniques to foster and support interaction in the classroom and school community. Communicate the mathematical thinking coherently and clearly to students.
11. Contribution to school organization	Know and understand the principal features of the education system, educational policy and practice, and professional responsibilities, participating actively in the professional community.
12. Personal commitment	Reflect a range of personal attributes necessary to work constructively within the school community, and pursue opportunities to grow professionally.

Source: Own elaboration.

Initial education for secondary mathematics teachers in Spain

Initial teacher education programs have undergone several changes during recent decades. Due to the introduction of the Bologna reform, the former Certificate of Pedagogical Aptitude (CPA, CAP in Spanish) was replaced with the Master Degree in Teacher Training in Secondary Education (MDTTSE). The disappearance of the CPA has been a substantial improvement, but the implementation of the MDTTSE has not been exempted from difficulties. Both programs are described below.

A brief historical review: the CPA

Before 2009, secondary education programs were based on a short-term course in view of obtaining the CPA. This certificate was regulated by ministerial order, dated July 14, 1971. The length of this classroom-based teaching program was initially 300 hours, with an unequal balance between theory and practice. The program was structured in two stages. In a first step, student teachers acquired pedagogical knowledge about psychology and sociology principles and teaching theories, while the second step was based on an internship in a high secondary school. In practice, the duration of CPA was reduced, becoming in some cases 80 hours of theory versus 40 hours of practice.

Next to its short length, its unstructured and inefficacious organization, its lack of pedagogical content knowledge, and teacher educators improperly trained, researchers criticized the fact that the CPA was not adequate to train prospective teachers. Moreover, graduating student teachers felt unsatisfied. Thus, in 2010 the Spanish education system launched a new initial education program, the MDTTSE. Consequently, the CPA disappeared.

The MDTTSE

In the academic year 2009/2010, the MDTTSE was implemented and regulated by the Ministry through order ECI/3858/2007, dated December 27, 2007 (Ministerio de Educación y Ciencia, 2007). In addition, it is to be verified by the National Agency for Quality Assessment and Accreditation (ANECA, Spanish acronym).

This program, considered as a branch within the social sciences, enables students to teach in secondary education and it is mandatory to apply for a teaching post in lower and upper secondary schools and vocational training centers; both in public and/or private secondary schools.

The MDTTSE shares characteristics of the CPA. For instance, both programs follow a consecutive model and build on a theoretical versus a practice-oriented stage. However, both are also dissimilar. For example, while the government used to regulate all CPA guidelines such as entry requirements, awarding the diploma and accreditation, control and management of the MDTTSE has become the full responsibility of higher education institutions. Moreover, the practical component of the MDTTSE is close to 40%, while in the CPA was less than 10%.

The size of the new teacher education program is 60 ECTS (European Credit Transfer and Accumulation System) and is set up as a one year full-time program. Generally, it consists of two theoretical classroom-based modules and an internship module, comprising of at least eighty percent of the credits. The internship module is set up by university faculties and higher secondary schools. Also distance/online universities guarantee such a face-to-face internship component.

The MDTTSE helps to train content specialist teachers, qualified to teach one specific subject. The most common specializations are: mathematics, physics and chemistry, biology and geology, technology, computing, language and literature, English, French, draw, music, philosophy, geography and history, economy, classical languages, professional training and guidance, educational guidance, and physical education.

Structure and organizational features

The MDTTSE is structured - as stipulated in the ministerial order - into three modules, which make up at least 52 of all the 60 ECTS:

- Generic module (at least 12 ECTS) consists on topics considered relevant for all teacher to know, such as educational theory, general principles of instruction, classroom management, curriculum theory, and so on. It is divided in three areas: *Personality development and*

learning, Educational contexts and processes, and Society, family and education.

- Specific module (at least 24 ECTS) including mathematics content knowledge and mathematics pedagogical content knowledge. It is also divided in three areas: *Additional training specific to the specialty chosen, Learning and teaching process specific to the specialty chosen, and Research and teaching innovation.*
- Internship (at least 16 ECTS) including a school-based experience (practicum) and the master's thesis.

Each institution has the autonomy to distribute the remaining 8 ECTS among generic, specific or optional courses. Consequently, we can expect broad differences in the number of ECTS assigned to each module when comparing different MDTTSE.

Entry requirements

Ministerial order ECI/3858/2007 (Ministerio de Educación y Ciencia, 2007) establish the following entry requirements to start the MDTTSE in Spain:

- accredited mastery of the competences related to the specialization the students wish to attend.
- a B1 level mastery of a foreign language according to The Common European Framework of References for Languages. If candidates are not accredited at this level, they must pass a language test organized by each institution.

According to the first condition, the entry requirements depend on the specialty chosen. In mathematics, applicants must either pass a mathematics test organized by each institution, or hold a direct admission bachelor degree. Nevertheless, each Spanish university has a high level of autonomy in determining which bachelor degrees allow students to enroll directly into the MDTTSE in mathematics. For instance, some universities accept any bachelor degree as entry requirement as long as students have attained a minimum of 60 to 120 ECTS in a bachelor degree covering mathematical subjects such as algebra, calculus, geometry or statistics. In addition, some institutions prioritize certain bachelor degrees, such as mathematics and statistics. Moreover, some universities let a fitting bachelor degree prevail over passing the specialization entry test. The former suggests a strong heterogeneity in Spanish entry requirements.

Standards for secondary mathematics teachers in Spain

According to Ministerial order ECI/3858/2007 (Ministerio de Educación y Ciencia, 2007), on finishing the MDTTSE, graduates will be able to:

- Know the content of curricula in the corresponding teaching specialty, as well as relevant teaching and learning processes.
- Plan, develop and assess the teaching and learning process, enhancing educational processes which facilitate the acquisition of competences of the respective teaching levels, taking into account students' level and backgrounds as well as their orientation, both individually and in collaboration with other teachers and professionals in the school.
- Seek, retrieve, process and communicate information (oral, printed, audiovisual, digital or multimedia), transform it into knowledge and apply it in the teaching and learning processes of their area of specialization.
- Specify the curriculum to be implemented in a school, collaborating in its planning. Develop and implement teaching methodologies both in groups and individually, adapted to the student diversity.
- Design and develop learning environments with special attention to equality, emotional education, values, equal rights and opportunities between men and women, citizenship education and respect for human rights that facilitates life in society, decision-making, and build a sustainable future.
- Acquire strategies to stimulate student effort and encourage his ability to learn both individually and in collaboration with others, and develop thinking and decision skills which enhance personal autonomy, confidence and initiative.
- Know the interaction and communication processes in the classroom, master necessary social skills to encourage learning and a team working in the classroom, and deal with discipline disorders and conflict resolution.
- Develop formal and informal activities fostering participation and culture within the school and its environment. Assume mentoring and guidance roles in a collaborative and coordinated way. Participate in the assessment, research and innovation of teaching and learning processes.

- Know the current regulations and institutional organization in the education system, and quality improvement approaches applicable to schools.
- Know and analyze the historical characteristics of the teaching profession, its current situation, perspectives and relation to different social realities.
- Inform and advise families about the teaching and learning process, and personal, academic and professional guidance of their children.

Teacher training should be organized towards teaching professional standards. However, how these competences are defined can be questioned. Some competences are completely redundant since some are contained in others, and there is potential ambiguity in how they should be understood.

On one hand, it seems to be a slight confusion between teacher competences and teacher standards. Notice that teacher competences refer to a combination of knowledge, skills, values and attitudes which lead to effective achievement of a task, while teacher standards describe what teachers believe, know, understand and are able to do as specialists in their fields.

On the other hand, considering the international list of standards for secondary mathematics teachers described above, it is possible to observe important differences when comparing Spain to other countries. The link between the twelve international standards for secondary mathematics teachers and the teacher competences standardized in Spain is fairly weak (see Table V).

TABLE V. Analysis of the international standards for teachers in the Spanish curriculum

Explicitly mentioned	Standard 4. Classroom management. Standard 5. Lesson planning. Standard 6. Assessment and mentoring	Standard 8. Inclusion and diversity. Standard 10. Communication skills. Standard 11. Contribution to school organization.
Implicitly mentioned	Standard 1. Mathematical content knowledge. Standard 3. Teaching and learning theories and processes.	Standard 9. Technology knowledge. Standard 12. Personal commitment.
Not mentioned	Standard 2. Mathematical pedagogical knowledge.	Standard 7. Developmental psychology.

Source: Own elaboration.

For instance, none of the Spanish competences refers to two of the international teacher standards: mathematical pedagogical knowledge (standard 2) and developmental psychology (standard 7). In Spain, competences are common to all specializations available in initial education programs for secondary teachers. Competences developed for mathematics teachers are exactly the same as competences for other subjects. Explicit competences related to mathematical pedagogical knowledge do not exist. Consequently, universities should develop and specify these competences according to the different specializations following their own criteria. Furthermore, none of the competences mention that prospective teachers should know and understand the stages of students' personality development in order to adapt the teaching and learning to support their needs.

In the same way, some other standards are barely mentioned. For instance, when it comes to mathematical content knowledge (standard 1), the depth of competency is very low. Also, in relation with teaching and learning theories and processes (standard 3), competences do not

allude to strategies for teaching and learning mathematics, and they neither specify the importance of justifying the approaches taken to learning and teaching mathematics and their impact on students. At the same time, the technology knowledge (standard 9) required seems to be pretty scarce. Beyond knowing and using information and communications technology systems, future teachers should design and develop learning experiences and assessments using digital tools. At the same time, previous studies point at the doubtful relevance of teaching commitment (standard 12) in the competency framework, in particular when it comes to intrapersonal skills and professional development. In this sense, prospective teachers should commit to the continual improvement of the teaching practice participating in activities for personal professional development.

Besides, in Spain, there is a lack of benchmarks which specify to what extent these teacher competences should be pursued and assessed. The experience of other countries like United Kingdom shows that teacher standards serve to assess and improve teacher training programs.

Research design and method

Sample

The MDTTSE is currently offered by 68 universities out of the 80 currently accredited in the Spanish University System³. Only 56 of them –38 public and 18 private– provide mathematics as a specialty. The MDTTSE is usually coordinated by Teacher Training and Education faculties since its establishment in the academic year 2009/2010.

It is important to note that the number of MDTTSE offered by universities can change every academic year, due to a minimum number of students required for a program. Apart from that, some institutions offer the mathematics specialization together with technology and computing. Furthermore, some MDTTSE in mathematics are set up as an inter-university master degree. Thus, the actual number of initial teacher education programs in mathematics is down to 51; 33 in public

³ Further information about universities and master student population can be found in <http://www.mecd.gob.es/> (Misnisterio de Educación, Cultura y Deporter, 2013).

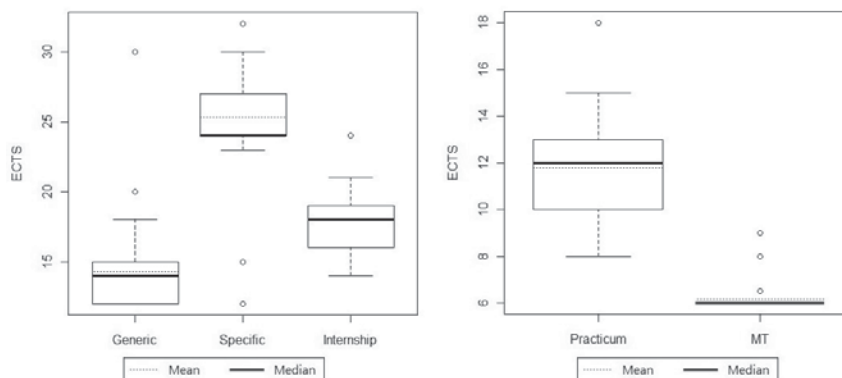
universities and 18 through private universities. Moreover, 39 universities offer only classroom-based learning. These courses - set up during two consecutive semesters - can be followed on a full-time or part-time basis.

Methodology

As it is mentioned before, the ministerial order that regulates initial teacher education programs in Spain puts forward quite general guidelines. Therefore, universities are largely autonomous in detailing the curriculum. Once common characteristics of teacher training programs have been described, our next goal is to analyze the significant differences arising from institutions' autonomy among the 51 initial education programs in mathematics offered in Spain.

For our purpose, we first represent the distribution of ECTS in a multiple box plot (see Figure I) in order to detect structural dissimilarities.

FIGURE I. Distribution of ECTS in each module in the MDTTSE in mathematics



Source: Own elaboration based on the data available on MDTTSE curriculums.

To develop a more comprehensive picture about the disparities in entry requirements, we analyzed information about the set of bachelor degrees accepted to engage directly in the MDTTSE in mathematics.

Building on the available information on university websites, a comprehensive list of 40 institutions –29 of which are public, and 11 are private– providing initial education for secondary mathematics teachers in Spain was considered. Due to the heterogeneity of direct admission bachelor degrees, they were classified according to 10 knowledge fields (see Table VI).

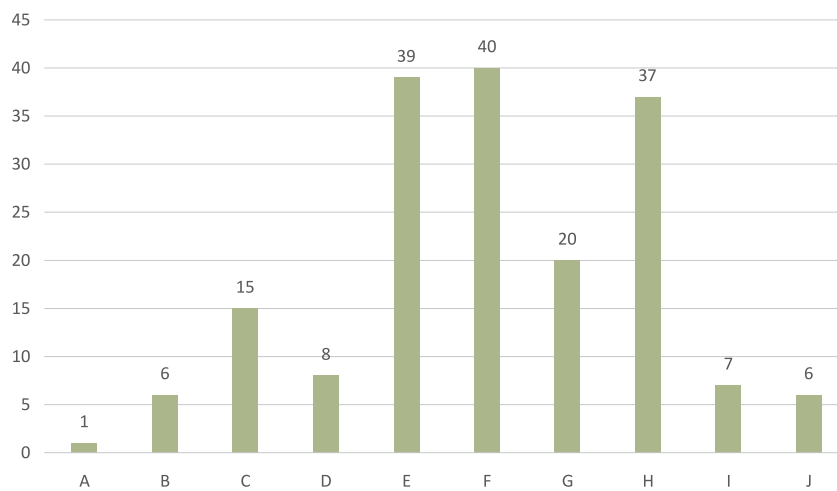
TABLE VI. Classification of fields of knowledge

Broad field	Detailed list
A. Education	Teacher training, education science.
B. Humanities and arts	Audio-visual techniques and media production, design, music, religion, history, philosophy, language, literature.
C. Social sciences, business and law	Economics, political sciences, psychology, sociology, journalism, library, information, marketing, administration, law.
D. Life sciences	Biology, biochemistry.
E. Physical sciences	Physics, astronomy, chemistry, geology.
F. Mathematics and statistics	Mathematics, statistics.
G. Computing	Computer sciences, data processing, networks, operating systems, software development, system design.
H. Engineering, manufacturing and construction	Chemical engineering electricity, electronics, mechanics, food processing, materials, mining and extraction, architecture, building and civil engineering.
I. Agriculture	Agriculture, livestock, forestry, fishery, veterinary.
H. Health and welfare	Dental, medicine, nursing, therapy, pharmacy, social care, social work.

Source: adapted from.

For the descriptive analysis, we represent in a bar graph (see Figure II) the number of universities providing initial education for secondary mathematics teachers that have at least one direct admission bachelor degree in the field of knowledge that it belongs to.

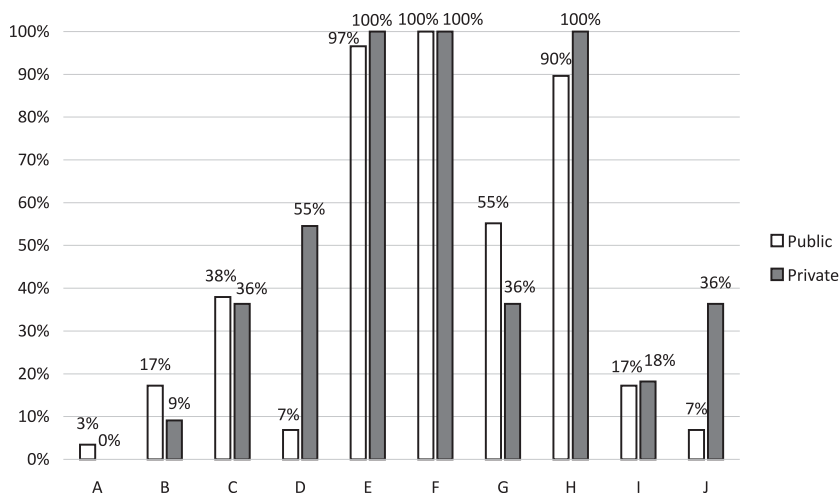
FIGURE II. Admission bachelor degrees to enroll directly into the MDTTSE in mathematics



Source: Own elaboration.

A deeper analysis shows disparities between private (11) and public (29) institutions when it comes to giving access on the base of specific bachelor degrees (see Figure III).

FIGURE III. Differences between public and private institutions providing the MDTTSE in mathematics when accepting specific bachelor degrees as entry requirements



Source: Own elaboration.

Results

Figure I clearly reflects an unequal distribution of ECTS between different initial education programs and question the extent to which all these programs can be aligned in terms of the competences being pursued and attained.

In specific and generic modules, the values of minimum, maximum and outliers point out a high degree of dispersion in the data. That means that there are broad differences between the load of generic and specific contents among the set of initial education programs. At the same time, median values indicate an asymmetric distribution in all variables.

In internship module, despite a smaller spread, variance between programs is also evident. According to the second box plot, a wide spread in practicum explains variance in internship module. With a minimum of

8 ECTS and a maximum value of 18 ECTS, a wide disparity is observed between some programs when it comes to the attention paid to the practicum. Bear in mind that a practicum commonly consists of two parts: an observational and an intervention practicum. During the observational practicum, students spend a short period of time observing professionals in their day-to-day teaching activities: planning, developing and organizing instruction, classroom management, assessment, mentoring, among other professional responsibilities, while in the intervention practicum they demonstrate their micro-level teaching skills. On the other hand, in around 92% of initial education programs in mathematics, the master's thesis requires 6 ECTS.

Figure II shows that while some institutions accept a large variety in initial degrees, others are very restrictive.

As expected, in all universities candidates with a bachelor degree in the field of mathematics and statistics (F) can enroll directly into a MDTTSE in mathematics in Spain. It should be noted that statistics degrees include a broad mathematical knowledge, and are not limited to the study of mere statistics and probability.

The same situation is found in physical sciences (E) and engineering, manufacturing and construction (H): almost all universities (97.5% and 92.5%, respectively) accept them as a direct admission bachelor degree. However, not all the engineering degrees reflect the same mathematics content load.

Universities vary largely to the extent they accept other bachelor degrees. About 50% of Spanish universities consider computing degrees (G) as an alternative pathway, and nearly 38% believe the same about social sciences, business and law (C) degrees. In this respect, it is important to note, that most part of the admission degrees in the field of social sciences, business and law (C) are connected with economics, finance, business administration, and accounting, which are more closely related to mathematical knowledge as compared to other degrees in the field of law, sociology, or geography.

But, around 15% of the universities still consider that a bachelor degree in humanities and arts (B), life sciences (D), agriculture (I), or/and health and welfare (J) present a sufficient mathematics base to become a higher secondary education teacher. This can be questioned. For instance, in most life sciences and health and welfare bachelor degrees the only mathematical knowledge being taught is limited to statistics. Algebra,

calculus, or geometry knowledge are not studied. This strange situation results from a situation in the 80's and first 90's, because due to a lack of graduates in mathematics, it became accepted that graduates in biology or chemistry, without a high-level training in mathematics, were nevertheless employed as mathematics teachers in secondary schools. In the same way, there is a lack of mathematical content in degrees such as occupational therapy or agricultural and food industry that are also accepted as entry degrees in some universities.

Only in one university, students holding a degree in education (A) are admitted. In addition, these students have to attend complementary courses related with infinitesimal calculus, matrix and vector calculus, and statistical knowledge.

But, is there any difference between public and private institution when accepting specific bachelor degrees as entry requirements? As figure III shows, while in some fields of knowledge there are considerable differences between public and private institutions, a weighted balance is reflected in others.

The only institution wherein students having an education degree can enroll directly in the MDTTSE in Spain is public. Bear in mind that some extra mathematical courses are required.

In social sciences, business and law (C), physical sciences (E), mathematics and statistics (F), and agriculture (I), there are barely any differences between public and private universities, whereas in humanities and arts (B), and engineering, manufacturing and construction (H) differences between both variables are larger.

In life sciences (D) as well as in health and welfare (J) there is a major predominance of private institutions. As we have pointed out before, bachelor degrees related with these knowledge fields have a substantial amount of statistical contents, not covering other mathematical branches such as algebra, calculus or geometry. On the other hand, more public institutions accept computing (G) bachelor degrees for direct admission than private. However, these degrees almost always include, at least, algebra, calculus and statistics knowledge, and in some cases discrete mathematics. Thus, the mathematical content in computing degrees is larger than in life sciences and health and welfare degrees, and they are strongly promoted in public institutions as an entry requirement.

Discussion

Spanish initial education programs for secondary mathematics teachers present broad differences compare to other countries in relation with organization, duration, entry requirements, level of the degree awarded at the completion of a teacher training program, and standards for future secondary mathematics teachers.

In Spain, prospective secondary teachers must, after obtaining a bachelor degree, complete an official one-year master course of 60 ECTS providing them with the theoretical and practical skills needed to join the teaching profession. Therefore, training programs for secondary teachers in Spain follow a consecutive model as in France, Germany and Italy. In other countries, initial teacher education programs are organized according to the concurrent model, while in others both routes are available.

At the same time, duration of initial education programs for secondary teachers vary widely from country to country, mainly depending on the model. In Spain, the overall length of study for secondary mathematics teachers is 5 (4+1) years, since the access to training programs is conditioned on graduation from a bachelor degree. Other countries with the same structure are Chile, France and United Kingdom.

In most countries, the minimum requirement to start secondary teacher education is an upper secondary education diploma, often in combination with *numerus clausus* policies, and/or further requirements such as competitive examinations, standardized tests or personal interviews. This is not the case in Spain. In view of enrolment in Spanish initial secondary teacher education, students must already hold a bachelor degree and a B1 level mastery of a foreign language. However, there are glaring discrepancies between Spanish universities in the type of bachelor degrees they allow to enroll in the training program. While some institutions accept a large assortment of initial degrees, others are quite restrictive. At the same time, there are disparities between public and private universities.

Finally, in Spain, the qualification awarded at the completion of a teacher training program is a master degree, comparable to the approach adopted in most European countries, and in contrast to other countries where the qualification is merely a bachelor degree (mostly organized according to the concurrent model).

Worldwide, a critical point of initial teacher education programs is the lack of educational standards establishing what skills, abilities, knowledge and values must be pursued and attained in teacher training programs. In few countries - such as Chile, Germany or United Kingdom - standards for initial teacher education are clearly defined. This is not the case of Spain where mathematics teacher training programs lack specific standards and benchmarks specifying a minimal level of attainment of the standards.

In the view of the authors of this report - building on examples presented in the international framework - alternative approaches should be adopted to ensure the quality of the teacher education system. In particular, they stress the establishment of explicit and operational standards to assess to what extent prospective - mathematics - teachers are qualified. Then, it will be necessary to supervise how universities implement these competences. On the other hand, a standardized mathematics test should be set in order to settle differences between institutions in relation with the large variety in admission degrees to enroll into the secondary mathematics teacher education program.

The results of this descriptive research present avenues for prospective action. First, we can analyze to what extent secondary mathematics student teachers currently attain standards as put forward in our international framework. This could be studied from the viewpoint of student teachers, recent graduates, teacher educators and principals. Secondly, this first avenue gives way to an analysis of critical competences weakly attained/pursued during the theoretical and practical teacher education experience. For this purpose, a national survey will be set up. To conclude, we repeat that the current and future studies aim at improving and ensuring the quality of mathematics teacher education in the Spanish teacher education system.

References

Avalos, B. (2005). Secondary Teacher Education in Chile: An assessment in the light of demands of the knowledge society. Retrieved from http://info.worldbank.org/etools/docs/library/211118/b_avalos.pdf

- Becker, E. S., Goetz, T., Morger, V., & Ranellucci, J. (2014). The importance of teachers' emotions and instructional behavior for their students' emotions – An experience sampling analysis. *Teaching and Teacher Education*, 43, 15–26. <http://doi.org/10.1016/j.tate.2014.05.002>
- Bolívar, A. (2007). La formación inicial del profesorado y su identidad profesional. *Estudios Sobre Educación*, 12, 13–30.
- Caspersen, J., & Raaen, F. D. (2013). Novice teachers and how they cope. *Teachers and Teaching*, 20(2), 189–211. <http://doi.org/10.1080/13540602.2013.848570>
- CEC. (2007). Improving the Quality of Teacher Education. Retrieved from http://www.atee1.org/uploads/EUpolicies/improving_the_quality_of_teacher_education_aug2007.pdf
- Echeita, G., & Pérez, P. (2010). Teacher Education For Inclusion. Country Report: Spain. Retrieved from <https://european-agency.org/sites/default/files/TE4I-country-report-for-web-Spain.doc>
- Erebus International. (2008). Scoping study on the development of teaching standards in the broader Asia-Pacific Region. Retrieved from [https://www.aei.gov.au/About-AEI/Policy/Documents/Brisbane Communique/Teaching_Standarts_pdf.pdf](https://www.aei.gov.au/About-AEI/Policy/Documents/Brisbane%20Communique/Teaching_Standarts_pdf.pdf)
- Escudero, J. M. (2009). La formación del profesorado de Educación Secundaria: contenidos y aprendizajes docentes. *Revista de Educación*, 350, 79–103.
- Esteve, J. M. (2006). La profesión docente en Europa: perfil, tendencias y problemática. La formación inicial. *Revista de Educación*, 340, 19–40.
- European Commission. (2013). Supporting teacher competence development for better learning outcomes. Retrieved from http://ec.europa.eu/education/policy/school/doc/teachercomp_en.pdf
- Eurydice. (2011). Mathematics Education in Europe: Common Challenges and National Policies. Retrieved from http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/132EN.pdf
- Font, V. (2013). La formación inicial del profesor de matemáticas de secundaria en España. *Revista Binacional Brasil Argentina*, 2(2), 49–62.
- Gutiérrez, J. M. (2011). La Formación Inicial del Profesorado de Secundaria. Del CAP al Máster. *CEE Participación Educativa*, 96–107.
- Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement*. New York: Routledge.
- Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of Teachers' Mathematical Knowledge for Teaching on Student Achievement.

- American Educational Research Journal*, 42(2), 371–406.
<http://doi.org/10.3102/00028312042002371>
- Llorent, V. (2012). The Institutes of Education Sciences [ICEs] and Teacher Training: A Path of Reform. *Procedia - Social and Behavioral Sciences*, 46, 3112–3118. <http://doi.org/10.1016/j.sbspro.2012.06.021>
- López-Goñi, I., & Goñi, J. M. (2012). La competencia emocional en los currículos de formación inicial de los docentes. *Revista de Educación*, 357, 467–489.
- Manso, J., & Martín, E. (2014). Valoración del máster de formación de profesorado de educación secundaria: estudio de caso en dos universidades. *Revista de Educación*, 364, 145–169. <http://doi.org/10.4438/1988-592X-RE-2014-364-258>
- Ministerio de Educación, Cultura y Deporte. (2013). Datos básicos del sistema universitario español. Curso 2013-2014. Retrieved from http://www.mecd.gob.es/dms/mecd/educacion-mecd/areas-educacion/universidades/estadisticas-informes/datos-cifras/DATOS_CIFRAS_13_14.pdf
- Ministerio de Educación y Ciencia. (2007). Orden ECI/3858/2007, de 27 de diciembre, por la que se establecen los requisitos para la verificación de los títulos universitarios oficiales que habiliten para el ejercicio de las profesiones de Profesor de Educación Secundaria Obligatoria y Bachillerato. *Boletín Oficial Del Estado*, 312, 53751–53753. Recuperado de <https://www.boe.es/boe/dias/2007/12/29/pdfs/A53751-53753.pdf>
- Musset, P. (2010). Initial Teacher Education and Continuing Training Policies in a Comparative Perspective: Current Practices in OECD Countries and a Literature Review on Potential Effects. *OECD Education Working Papers*, 48. Retrieved from <http://dx.doi.org/10.1787/5kmbphh7s47h-en>
- NARIC. (2012). An assessment of international teacher training systems : country profiles. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/193361/DFE-RR243a_country_profiles.pdf
- NCTM. (2012). NCTM CAEP Standards (2012) – Secondary (Initial Preparation). Retrieved from http://www.nctm.org/uploadedFiles/Standards_and_Positions/CAEP_Standards/NCTM_CAEP_Standards_2012_-_Secondary.pdf
- OECD. (2014). *Indicator D6: What does it take to become a teacher? Education at a Glance 2014: OECD Indicators*. OECD Publishing. <http://doi.org/http://dx.doi.org/10.1787/888933120252>

- Quality Assurance Agency. (2000). Benchmark information on the standard for initial teacher education in Scotland. Retrieved from <http://www.scotland.gov.uk/Resource/Doc/156271/0041907.pdf>
- Rico, L. (2004). Reflexiones sobre la formación inicial del profesor de matemáticas de secundaria. *Profesorado, Revista de Currículum Y Formación Del Profesorado*, 8(1), 1–15.
- Rico, L., Gómez, P., & Cañadas, M. C. (2014). Formación inicial en educación matemática de los maestros de Primaria en España, 1991-2010. *Revista de Educación*, 363, 35–59. <http://doi.org/10.4438/1988-592X-RE-2012-363-169>
- Stokking, K., Leenders, F., De Jong, J., & Van Tartwijk, J. (2003). From student to teacher: reducing practice shock and early dropout in the teaching profession. *European Journal of Teacher Education*, 26(3), 329–350. <http://doi.org/10.1080/0261976032000128175>
- Struyven, K., & Vanthournout, G. (2014). Teachers' exit decisions: An investigation into the reasons why newly qualified teachers fail to enter the teaching profession or why those who do enter do not continue teaching. *Teaching and Teacher Education*, 43, 37–45. <http://doi.org/10.1016/j.tate.2014.06.002>
- Tatto, M. T., Schwille, J., Senk, S. L., Ingvarson, L., Rowley, G., Peck, R., ... Reckase, M. (2012). *Policy, Practice, and Readiness to Teach Primary and Secondary Mathematics in 17 countries. Findings from the IEA Teacher Education and Development Study in Mathematics (TEDS-M)*. Amsterdam: IEA.
- UNESCO. (2012). *International Standard Classification of Education ISCED 2011*. Canada: UNESCO Institute for Statistics.
- UNESCO. (2014). *ISCED Fields of Education and Training 2013 (ISCED-F 2013)*. Canada: UNESCO Institute for Statistics.
- Valle, J. M., & Manso, J. (2011). La nueva formación inicial del profesorado de Educación Secundaria : modelo para la selección de buenos centros de prácticas. *Revista de Educación*, 354, 267–290.

Contact address: Laura Muñiz-Rodríguez. Universidad de Oviedo, Departamento de Matemáticas, Facultad de Ciencias. Avenida Calvo Sotelo s/n, 3307 Oviedo, Asturias, España. E-Mail: uo205132@uniovi.es