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## Are Future Mathematics Teachers Ready for the Profession? A Pilot Study in the Spanish Framework

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### Abstract

Prospective teachers' preparation throughout initial teacher education programmes is crucial in order to guarantee future teachers' readiness for the job. Initial teacher education programmes are expected to provide student teachers with the desired competences to build-up their professional identity as teachers. As part of a wider research, this paper presents the results of a pilot study with a double aim. First, to assess the quality of an instrument to analyse the extent to what initial teacher education programmes are successful in training prospective secondary mathematics teachers in view of a framework of professional teaching competences in Spain. As a consequence, to perform a preceding evaluation of initial teacher education programmes in mathematics. An online-based survey was conducted by 51 graduate students from initial teacher education programmes for future secondary mathematics teachers in Spain. Statistical analysis suggested weak levels of attainment in all assessed competences. The competence level was in all cases lower than the 80% of mastery level benchmark desired for a competence to be attained. The results of the pilot survey support the validity of the instrument in view of a coming study to be carried out on a larger scale.

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**Keywords:** Competences; mathematics; student teachers; teacher education.

### 1. Introduction

The quality of teaching is determined, together with other factors, by the quality of teachers (Hill, Rowan & Ball, 2005; OECD, 2005). Hence, ensuring competent teachers are recruited for the teaching profession is a primary goal for educational policy makers. But, what should teachers know and be able

to do? Today's society does not only require future teachers to demonstrate specific subject content knowledge, but also to know how students learn and to recognise the factors influencing the learning process, to use appropriate teaching and learning strategies making use of information and communication technologies, to be aware of students' background, prior knowledge, needs and social or cultural contexts, to be able to engage students in their learning process ensuring a favourable classroom environment, to assess learning and report students' progress building reliable relationships with students, parents and colleagues, among other things (Koehler & Mishra, 2009; Mishra & Koehler, 2006; Shulman, 1986, 1987). This combination of knowledge, skills and values is usually defined as teaching competences (European Commission, 2013). Nevertheless, there are also research findings which highlight that student teachers' practices are furthermore significantly influenced by their beliefs, personal values and critical background knowledge (Tabachnick & Zeichner, 1984).

Within the Spanish context, due to the implementation in 2006 of the Organic Law of Education and in line with the adaptation of Spanish universities to the European Higher Education Area (EHEA), initial teacher education programmes for future secondary teachers have undergone several changes (Gutiérrez, 2011). Since the academic year 2009/2010, in order to become a specialist teacher at secondary education level, a bachelor degree is required in a specific field of knowledge related to the specialisation in which prospective teachers want to graduate – for instance, mathematics –, followed by a postgraduate degree of 60 ECTS (European Credit Transfer System), known as the Master Degree in Teacher Training in Secondary Education (henceforth MDTTSE). Despite recent research improvement of initial teacher education programmes in Spain, research points at critical deficiencies in prospective teachers when completing the MDTTSE (Martínez-Abad, Olmos-Migueláñez & Rodríguez-Conde, 2015; Muñoz-Rodríguez, Alonso, Rodríguez-Muñoz & Valcke, 2016; Serrano & Pontes, 2015).

The twofold goal of this pilot study is to assess the validity of an instrument designed to examine the quality of initial teacher education programmes in mathematics in Spain and to analyse the extent to which secondary mathematics student teachers do acquire a set of teaching competences during initial teacher education programmes in Spain. The results will allow to identify critical competences weakly pursued/attained on the base of theoretical and practical initial teacher education experiences.

This study was guided by the following research questions:

- a. What is the future secondary mathematics teachers' perception of teaching competences in terms of their importance for the profession?
- b. To what extent do future secondary mathematics teachers indicate they have been trained towards teaching competences during the MDTTSE?
- c. To what extent do future secondary mathematics teachers indicate they are ready for the job, building on their mastery of teaching competences during the MDTTSE?

## **2. Research methods**

Data collection was based on an online survey. A questionnaire was individually administered via email and implemented through LimeSurvey®, open-source software for on-line questionnaire design, delivery and administration. Data analysis was performed using SPSS® and Weft QDA. Some items,

already described and validated in the Teacher Education and Development Study in Mathematics (TEDS-M), were taken into account (Brese & Tatto, 2012). Note that the TEDS-M was only undertaken for primary teachers in Spain (Tatto et al., 2012).

### 2.1. Sample

All graduate students from the MDTTSE in mathematics in Spain since its implementation in the academic year 2009/2010 represented the target group of this pilot study. A non-probability sampling technique was used taking into account the lack of access to a specific number of the population being studied. In particular, the participants' selection was made through convenience sampling in order to achieve an adequate sample size in a relatively easy and inexpensive way. Of the 205 invitations sent, 51 participants from eight public Spanish universities answered the questionnaire. The response rate – around 24.9% – was coherent for an internet-based survey. The average age of the graduate secondary mathematics teachers participating in the pilot study was 30.82 years old (SD = 5.465), ranging from 23 to 48 years old. The majority of the participants, 72.5%, were women.

### 2.2. Instrument

The questionnaire consisted of three sections. The first section was composed of a series of background questions focusing on indicators about the participants' personal profile (e.g., age, gender), academic background (e.g., bachelor degree, level of marks at university, mathematical background), initial teacher education programme characteristics (e.g., university, academic year, area of specialisation, admission requirements), and motivation for teaching mathematics (e.g., reasons for becoming a teacher, future teaching intentions).

The second section was based on a framework of thirty-three competences required for future secondary mathematics teachers, clustered around twelve domains of knowledge. This framework was previously designed, built on existing theoretical models – such as the TPACK model (Koehler & Mishra, 2009; Mishra & Koehler, 2006; Shulman, 1986, 1987) – and international frameworks of teaching standards (see e.g., National Council for Accreditation of Teacher Education, 2008; Training and Development Agency for Schools, 2008), and then validated through an expert panel consultation process for the purpose of this research (Muñiz-Rodríguez, Alonso, Rodríguez-Muñiz & Valcke, 2015). Each competence was presented as a statement and participants were invited to indicate on the base of a seven-point Likert scale, from 1 '*To an extremely small extent*' to 7 '*To an extremely large extent*':

- a. the importance of each competence for the teaching profession as a secondary mathematics teacher;
- b. the extent to which each competence had been pursued/covered during the MDTTSE; and
- c. the extent to which each competence was attained/mastered by the time student teachers graduated.

The last section included one question concerning the participants' opinion about the survey, e.g., adequacy of the questions, wording mistakes that disrupt comprehension, response time, among other difficulties that might have arisen during the survey. Answers to these questions provided valuable feedback in view of the improvement of the instrument.

### 3. Findings

#### 3.1. Quality of the research instrument

The questions in the first section were derived from the TEDS-M survey, reflecting good validity and reliability. Items about competences were based on the competence framework validated by experts in a previous phase. On the base of the present study, a psychometric analysis of the three scales about (a) importance, (b) level of pursuance, and (c) perceived mastery level of the competences, revealed high reliability (Cronbach's alpha: importance = 0.955, pursuance = 0.973, perceived mastery = 0.977). Responses to the last survey question showed all items to be clear, consistent with the MDTTSE curriculum and fit to be answered.

#### 3.2. Graduate secondary mathematics teachers' background

In total, 98% of the participants entered the MDTTSE in mathematics holding a direct admission bachelor degree. However, data reflected a rather heterogeneous academic background. Although mathematics and various engineering degrees – industrial, civil, telecommunications, forestry, mining, aeronautic, computer, mechanical, industrial design, and cartography – were predominant, alternative degrees such as business administration and management, chemistry, architecture, and statistics also resulted from the participants' responses. In order to simplify further analysis, the set of bachelor degrees was classified into three big groups (see Table 1).

**Table 1.** Graduate secondary mathematics teachers' academic background.

Group	Bachelor degree	Percentage
Mathematics	Mathematics	43.1%
Engineering	Industrial, civil, telecommunications, forestry, mining, aeronautic, computer, mechanical, industrial design, cartography	41.2%
Others	Business administration and management, chemistry, architecture, statistics	15.7%
Total		100%

The majority of participants indicated their grade after passing university exams was either '*pass*' (cum fructu) or '*remarkable*' (cum laude) (56.9% and 37.2%, respectively). Only two participants ranked their academic achievement as '*outstanding*' (magna/summa cum laude). Nevertheless, results from the correlational analysis showed a non-significant relationship between the variables bachelor degree and academic achievement.

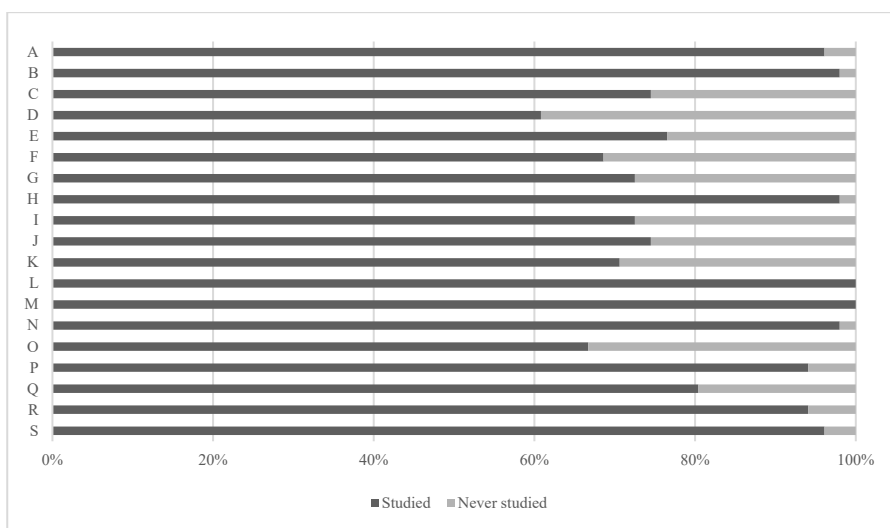
In order to analyse the future secondary mathematics teachers' mathematical background, participants were asked whether or not they had ever studied particular mathematical topics before entering teacher education. Nineteen mathematical topics from the TEDS-M survey (Brese & Tatto, 2012), classified into four domains of mathematical knowledge, were examined (see Table 2).

**Table 2.** Mathematics topics by domain of knowledge.

Discrete structure and logic	Geometry	Continuity and functions	Probability and statistics
A. Numbers and operations	G. Foundations of geometry or axiomatic geometry	L. Introduction to calculus	R. Probability
B. Linear algebra	H. Analytic or coordinate geometry	M. Calculus	S. Theoretical or applied statistics
C. Set theory		N. Multivariate calculus	
		O. Advanced calculus, real	

D. Abstract algebra	I. Non-Euclidean geometry	analysis or measure theory
E. Applied or discrete mathematics	J. Differential geometry	P. Differential equations
F. Mathematical logic	K. Topology	Q. Complex functions or functional analysis

Half of the topics – A, B, H, L, M, N, P, Q, R and S – were studied by more than 80% of the participants before entering the MDTTSE. The percentage of respondents who studied the other topics – C, D, E, F, G, I, J, K, and O – ranged between 60.8% and 76.5% (see Figure 1).



**Fig. 1.** Graduate teachers' mathematical background.

The next step was to analyse the relationship between the bachelor degree and the mathematical topics studied before entering the MDTTSE in mathematics. For every domain, a new variable was computed as the sum of the values of the related variables. Next, a correlational analysis was performed between the participants' bachelor degree and the number of topics studied in each domain, based on an 80% of the mastery level (Zimmerman & Dibenedetto, 2008). Results indicate that the bachelor degree significantly influences the mathematical content knowledge studied by graduate secondary mathematics teachers, except for the probability and statistics domain (this difference is discussed in the next section).

In order to analyse the graduate secondary mathematics teachers' motivation for the teaching profession, participants were shown a list of six reasons for becoming a teacher. Items were derived from the TEDS-M survey (Brese & Tatto, 2012). Each reason was considered as an independent variable. Both internal/vocational (talent for teaching, working with young people, teaching as a challenging job) as well as external/professional (teacher salaries, long-term job security) motivations to become a mathematics teacher were analysed. '*I love mathematics*' was the most important reason for becoming a secondary mathematics teacher. On average, internal or vocational reasons, such as having a talent for teaching or working with young people, were selected most by the participants, rather than external or professional reasons, such as being attracted by teacher salaries or seeking the long-term security associated with the teaching profession. Seeing teaching as a challenging job was

mainly selected as a moderate reason by a major proportion of the graduate secondary mathematics teachers participating in the pilot study (see Figure 2).

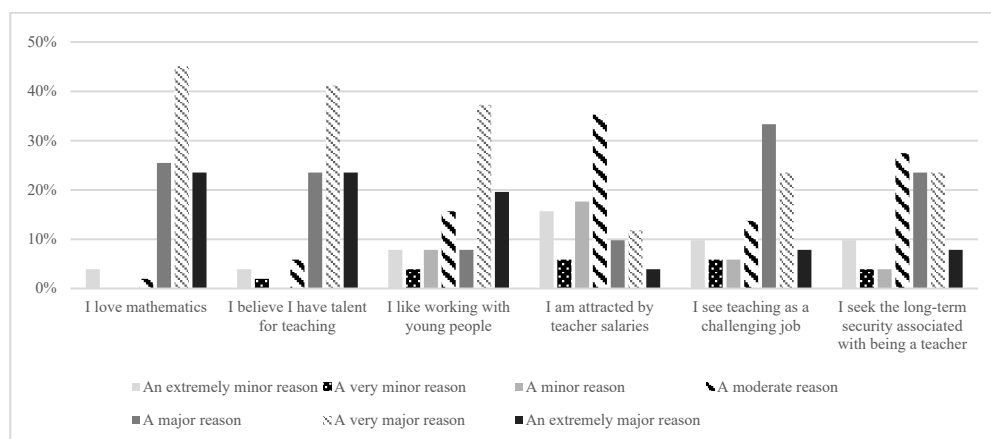


Fig. 2. Graduate teachers' reasons for becoming a teacher.

The participants' perception about their future in the mathematics teaching profession was used as an alternative measure of motivation. The survey included the question 'How do you see your future as a secondary mathematics teacher?' A seven point Likert scale from 1 'I will probably not seek employment as a teacher' to 7 'I expect it to be my lifetime career' was used. Nearly 14% of the participants' responses were lower than or equal to 3 and around 25.5% answered either 4 or 5. On the other hand, about 60.5% expect being in the teaching profession for a long time with ratings between 6 and 7.

### 3.3. Competences for future secondary mathematics teachers

Mean values from the participants' perception about the importance of the set of teaching competences ranged from 5.02 to 6.33 on the seven-point Likert scale (see Table 3). The most important domain according to the graduate secondary mathematics teachers was 'mathematical pedagogical knowledge' as opposed to 'contribution to school organisation' with the lowest mean value.

With a minimum of 3.31 and a maximum of 5.14, participants reported most competences were not intensively pursued during their MDTTSE (see Table 3). The competence domains 'contribution to school organisation' or 'assessment and mentoring' seemed to be mostly overlooked, as opposed to 'lesson planning' reported as the competence domain pursued to the largest extent.

Similar results were obtained regarding the attainment level for each competence, with mean values ranging from 3.55 to 5.04 (see Table 3). The three least attained competence domains were 'contribution to school organisation', 'assessment and mentoring' and 'mathematical content knowledge', whereas 'lesson planning' seemed to be mastered to the highest extent.

**Table 3.** Graduates' perceptions about importance, pursuance and mastery level of competences.

Competence framework	Importance M(SD)	Pursuance M(SD)	Mastery M(SD)
<b>Mathematical content knowledge.</b>			
MCK1. Know and understand mathematical concepts, ideas, theories and procedures according to different mathematical branches such as calculus, algebra, geometry, discrete mathematics, statistics and probability, and measurement.	6.00 (1.077)	3.96 (1.442)	4.02 (1.516)
MCK2. Know the history and recent findings of mathematics to convey a dynamic mathematical perspective.	5.24 (1.274)	3.75 (1.412)	3.76 (1.491)
<b>Mathematical pedagogical knowledge.</b>			
MPK1. Identify students' background and prior mathematical knowledge, as well as difficulties and mistakes, and apply those processes that can help students to face and solve them.	6.22 (1.083)	4.16 (1.541)	4.12 (1.395)
MPK2. Communicate and represent mathematical thinking coherently and clearly both orally and in writing.	6.33 (0.887)	4.20 (1.536)	4.47 (1.641)
MPK3. Make connections between mathematical concepts and other subject areas and real-life problems.	6.20 (0.960)	4.29 (1.591)	4.47 (1.515)
MPK4. Know relevant findings from teaching mathematics research as guidance for professional practice in the classroom.	5.45 (1.238)	3.90 (1.628)	3.96 (1.536)
<b>Teaching and learning processes.</b>			
TLP1. Select creative and innovative strategies for teaching and learning mathematics appropriate to students' needs.	5.92 (1.163)	4.39 (1.550)	4.41 (1.458)
TLP2. Be able to explain the impact on students of the strategies adopted for mathematical learning.	5.24 (1.176)	3.63 (1.399)	3.63 (1.356)
TLP3. Use a wide variety of materials and resources, such as games, puzzles, riddles, and technological devices, for teaching and learning mathematics.	5.73 (1.234)	4.43 (1.700)	4.45 (1.540)
TLP4. Know resources for mathematics teachers, such as mathematical research journals, professional mathematics organisations web sites, among others.	5.27 (1.060)	4.10 (1.300)	4.20 (1.265)
<b>Classroom management.</b>			
CM1. Enforce rules and routines of behaviour in classroom practice during mathematics lessons, in accordance with the school behaviour policy.	5.47 (1.155)	3.73 (1.601)	4.04 (1.574)
CM2. Use a variety of techniques to motivate students to develop enthusiasm for and interest in mathematics.	6.24 (1.142)	4.12 (1.716)	4.33 (1.717)
CM3. Make efficient use of classroom space to accommodate different learning techniques both collaboratively and individually.	5.29 (1.361)	3.78 (1.579)	3.94 (1.690)
CM4. Promote mathematical learning situations that allow students to ask questions themselves, investigate, and seek answers.	5.84 (1.065)	3.94 (1.502)	4.02 (1.435)
<b>Lesson planning.</b>			
LP1. Plan well-structured lessons that address appropriate learning goals, considering national mathematics curricula standards.	5.82 (1.090)	4.67 (1.583)	4.67 (1.506)
LP2. Know the national curriculum in Spain, identify its different elements and its application in the area of mathematics in secondary education.	5.49 (1.206)	5.14 (1.400)	5.04 (1.385)
LP3. Set homework and plan other out-of-class activities to reinforce the mathematical knowledge that students have previously acquired.	5.45 (1.222)	3.76 (1.544)	4.10 (1.688)
<b>Assessment and mentoring.</b>			
AM1. Employ different methods and techniques to assess students' mathematical learning that are rigorous, objective and fair.	5.69 (1.273)	4.06 (1.542)	4.08 (1.495)
AM2. Use the results obtained from the assessment to diagnose difficulties, set goals and plan future learning experiences within the area of mathematics.	5.76 (1.210)	3.75 (1.495)	3.86 (1.429)
AM3. Provide constructive, purposeful and timely feedback to students, their families, and school authorities.	5.67 (1.089)	3.57 (1.578)	3.73 (1.484)

Competence framework	Importance M(SD)	Pursuance M(SD)	Mastery M(SD)
<b>Developmental psychology.</b>			
DP1. Know student characteristics (e.g., motivation, attitudes...) and their social context.	5.96 (1.038)	4.31 (1.435)	4.47 (1.433)
DP2. Know the stages of student cognitive development and its influence on mathematics learning.	5.78 (1.083)	4.65 (1.309)	4.51 (1.433)
DP3. Adapt the teaching process to support students' learning at different stages of development using adequate strategies and methods.	5.75 (0.997)	4.22 (1.419)	4.14 (1.470)
<b>Inclusion and diversity.</b>			
ID1. Identify different student needs, including those with special educational needs, high ability, and/or disabilities.	6.20 (0.749)	4.12 (1.608)	3.92 (1.495)
ID2. Adapt teaching to respond to the strengths and needs of all students, designing differentiated instruction that addresses student diversity and encourages an inclusive education.	5.84 (1.027)	4.00 (1.697)	4.02 (1.594)
ID3. Know when and about which aspects to seek support and to cooperate with specialised supporting staff for students with specific educational needs.	5.80 (0.849)	3.94 (1.793)	3.88 (1.751)
<b>Technology knowledge.</b>			
TK1. Apply information and communication technologies within educational settings and mathematics teaching, analysing its impact on mathematics learning.	5.63 (1.058)	4.51 (1.554)	4.57 (1.404)
<b>Communication skills.</b>			
CS1. Use effective verbal and non-verbal communication techniques to foster and support interaction in the classroom and in the school community.	5.57 (1.044)	3.96 (1.661)	4.04 (1.536)
<b>Contribution to school organisation.</b>			
CSO2. Contribute in the design of the comprehensive education plan and common school activities with special attention to teaching quality improvement.	5.02 (1.208)	3.65 (1.585)	3.88 (1.519)
CSO3. Participate actively in school decision making, especially in those that apply to the mathematics department.	5.25 (1.214)	3.31 (1.581)	3.55 (1.527)
<b>Personal commitment.</b>			
PC1. Exhibit personal attributes – such as enthusiasm for mathematics and its learning, care and respect for the students, autonomy, self-esteem – that assist to engage students in their learning and maximise their achievement.	6.16 (1.120)	4.10 (1.513)	4.45 (1.629)
PC2. Contribute to the improvement of mathematics teaching by actively engaging students and collaborating with colleagues in mathematical activities both inside and outside the classroom.	5.92 (0.977)	4.00 (1.549)	4.35 (1.610)
PC3. Commit to teaching professional development, participating in training programmes for mathematics teachers.	5.71 (0.944)	3.53 (1.515)	4.04 (1.788)

**Note.** M = Mean. SD = Standard Deviation.

Next, a one-sample t-test was used in order to analyse whether perceived attainment levels were in line with mastery learning criteria (Zimmerman & Dibenedetto, 2008). A benchmark of 80% was put forward. On a seven-point Likert scale this is equivalent to a rating equal or higher than 6. On the base of a one-sample t-test with 6 as the standard and a significance level set at  $p < .05$ , results showed significant differences between the attainment level of competences and the mastery level benchmark. Attainment levels were in all competences consistently lower than the mastery level benchmark.



#### **4. Conclusions**

Results of this pilot study support the validity and reliability of the instrument designed to analyse the quality of the MDTTSE in mathematics in Spain and show how the research methods seem appropriate to be adopted in a future large-scale study. Next to a focus on background characteristics, the present study has especially centred on the perceptions of recent graduates from the MDTTSE in mathematics about teaching competences.

Most graduates from the MDTTSE in mathematics are women. This was also observed by the TEDS-M where most future teachers at primary and secondary education were females, both in Spain and in many other participating countries (Tatto et al., 2012). These findings support the predominance of women in the teaching profession over the years.

Although a large proportion of graduate secondary mathematics teachers hold a mathematics or an engineering degree, the future secondary mathematics teachers' academic background remains very heterogeneous. This can be critical since mathematical training varies largely between degrees and/or universities. For instance, while in some universities students have to attain at least 24 ECTS to 33 ECTS related to specific mathematics topics, in some other degrees/universities this ranges between 18 ECTS (e.g., forest or civil engineering) to 30 ECTS in computer engineering. These differences increase when comparing with former engineering curricula, where mathematical training consisted of nearly 50 ECTS.

In this sense, the results of this pilot study emphasise how the nature of the bachelor degree significantly influences the mathematical content studied before entering the MDTTSE in mathematics, except for the probability and statistics domain. Analogous findings were obtained in the TEDS-M, where results also varied significantly depending on the admission policies from the programmes concerned (Tatto et al., 2012). Hence, the adequacy of some bachelor degrees as direct admission degrees to enter the MDTTSE in mathematics can be questioned on the base of a too limited mathematical content background. Nevertheless, there are also research findings in the context of the MDTTSE in mathematics in Spain, which prove there is no cause-effect relationship between the future secondary mathematics teachers' bachelor degree and mathematical content knowledge (López, Miralles & Viader, 2013). These authors also question to what extent students entering the MDTTSE in mathematics have a solid specific subject content knowledge.

As explained above, the results were less clear when focusing on mathematics content related to the probability and statistics domain. The underlying cause of that difference lies in the generic nature of these topics. It is quite feasible all bachelor degrees – even those in the social sciences branch – cover in a rather broad sense content related to probability (R) and theoretical or applied statistics (S). In this sense, these topics do not illustrate more specific differences between bachelor curricula regarding probability and statistics content. Though these items are in line with the TEDS-M survey, these categories will be more specifically defined in view of a coming study, since they do not represent the differences in mathematical content between mathematics and engineering degrees.

Results about the graduate secondary mathematics teachers' motivation for teaching mathematics were also in line with the TEDS-M findings (Tatto et al., 2012). In this sense, internal or vocational reasons overrule external reasons. This was also observed by other research studies, revealing that the

graduates' teaching commitment is strongly related to their entrance in the teaching profession (Caires & Almeida, 2005; Rots, Aelterman, Vlerick & Vermeulen, 2007). But, despite their motivation, respondents experience difficulties to find a position as a secondary mathematics teacher. This can be due to high unemployment rates during the last years in Spain.

All teaching competences are considered as important by prospective teachers. But – and this is critical – competences seem to be weakly pursued and attained during the MDTTSE in mathematics. This results in a lower readiness for the profession. In particular, competences related to 'mathematical content knowledge' seem to be overlooked, next to 'contribution to school organisation' and 'assessment and mentoring'. These findings about competences at a critical mastery level in graduate secondary mathematics teachers confirm previous results about the level of development acquired in core competences – not only mathematics-related competences – in the MDTTSE in Spain (Serrano & Pontes, 2015).

The conclusions of this pilot study already give clear directions when analysing the quality of initial teacher education programmes in mathematics in Spain and suggest key factors that influence the future secondary mathematics teachers' readiness for the job. The validation of the instrument allows conducting a large-scale study with a multi-actor perspective – involving both trainee teachers and teacher educators – that will enrich the results. In order to explain our findings, competences will be analysed distinguishing two different settings: theoretical versus practical.

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