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We present a comparative micro-study analyzing whether the changes made to the admission requirements to the primary teacher training programs of the Universitat Autònoma de Barcelona and the University of Helsinki in the academic year 2017-18 have had an impact on the background mathematical knowledge of those admitted to the programs. We are interested in finding elements that provide information for university admission policies. Our results show that significant changes only took place in Barcelona and these were a consequence of the variations in the academic profile of the students admitted. We conclude that working with a context-bound instrument, while making comparison difficult, directs the researchers' attention to the need for an in-depth theoretical discussion about the mathematical knowledge of candidates to initial teacher education programs and a methodological discussion on how to evaluate this knowledge.

Keywords: University access requirements, primary teaching degree, background mathematical knowledge.

Introduction

Our study is among those that attempt to determine what factors influence the development of mathematical knowledge for teaching during teacher education. According to Blömeke and Delaney (2012), some of these variables are the institutional characteristics of each program, the idiosyncrasies of the national and social context, and the individual characteristics of the students attending the programs. The survey we present here is a small part of an emerging comparative study that aims to contribute to the discussion of university policies regarding access to primary teacher education programs while promoting a theoretical debate about what the desirable mathematical knowledge of students admitted to these programs would be (for more details about the project, see e.g. Albarracín, Gorgorió, Laine, & Llinares, 2018; and Gorgorió et al., 2017). We understand that the admissibility criteria and the requirements for access to educational programs, as institutional particularities, contribute to defining the individual characteristics of their students. We assume that the mathematical knowledge with which students access primary teaching programs – henceforth, background mathematical knowledge – influences the development of the knowledge needed to teach mathematics during their education.

As educators of primary school teachers, we are interested in finding elements that provide information for university admission policies so that requirements can be established to ensure a minimum of mathematical knowledge among admitted students. Comparative studies between

different national realities that evaluate the mathematical knowledge of the candidates in relation to the admission criteria can help to explain the success differences between the different training programs, thus identifying variables that may otherwise remain hidden in national studies and hence remain unquestioned.

Since 2014, at the Universitat Autònoma de Barcelona, Catalonia – henceforth BCN – we have been evaluating the background mathematical knowledge of students admitted to the primary teaching program through a specific test. In the 2016-17 academic year, we decided to also administer the test to the students admitted to the Master of Education degree at the University of Helsinki, Finland – henceforth HEL – to study the results comparatively, taking the entrance requirements into account. We then observed that students at HEL performed significantly better than students at BCN.

In this paper, we present a comparative micro-study analyzing whether the changes introduced in the 2017-18 academic year regarding requirements for admission to the primary teacher training programs in Catalonia and at the University of Helsinki have had an impact on the background mathematical knowledge of those admitted to the programs. The changes are of a very different nature and have to do with the idiosyncrasies of the respective university and school systems. For the students admitted to a teaching degree in Catalonia, and in particular to BCN, September 2017 was the first time they had to pass a specific mathematics test. At HEL the change consisted in increasing the proportion of candidates for whom not only the VAKAVA-test and suitability test but also the mathematics and Finnish grades of the matriculation examination were considered for admission.

We exploited quantitative data collected in the academic years of 2016-17 and 2017-2018, i.e. before and after changes took place in the admission criteria both at BCN and HEL. Here we discuss how the changes introduced have impacted students' performance on the test, comparing the performance across years, both within and between universities. We are especially interested in seeing whether the differences occur as result of the changes in the academic profile of the admitted students prior to their University studies.

Admission to a primary teaching degree at BCN and HEL

The recent introduction of the requirement to pass a specific mathematics test for admission to the primary teaching degrees in Catalonia justifies the presence of BCN in the research study. Since the results of the first PISA Study were published in 2000, there has been widespread international recognition of the success of Finland's educational model. Even though this success is due to many factors, the most important aspect is believed to be the quality and competence of its teachers (Salhberg, 2011). For this reason, it seemed logical to include a Finnish program in this study. In addition, since the policies and admission requirements to the primary teaching program in Helsinki are very different from the Spanish ones, we consider it interesting to compare HEL and BCN.

Since 1979, primary teachers in Finland need to have completed a Master of Education degree (300 ECTS). After compulsory education, youngsters can enter the job market directly or instead attend either university-preparatory Upper Secondary School or Vocational School. At Upper secondary school, students can choose to do either intermediate mathematics or advanced mathematics. At the

end of Upper Secondary School, students take the Finnish Matriculation Examination, *Ylioppilastutkinto* in Finnish (henceforth YLIO), which is the only national-level test in Finland. Each examinee is required to complete at least four exam papers, only one of them (mother tongue) being mandatory. The remaining three are chosen by the student and may include one in mathematics, either intermediate or advanced. Graduates of Vocational School may also gain admission to university. In Finland, students interested in becoming primary teachers, after passing the YLIO, must go through a special two-stage application process. The first stage involves taking an exam (the so-called *VAKAVA testi*) based on a set of education-related readings. Those who perform well on this exam go on to the second stage, a suitability test that assesses their motivation to study and suitability to work as teachers. Universities in Finland agree on the number of new admissions in cooperation with the Ministry of Education. At HEL, fewer than 10% of applicants are accepted annually for the primary teacher education program. In 2016-17, 48 students (40%) were selected based on the suitability test alone and 72 students (60%) were selected based on the suitability test and their grades in the YLIO in 4 subjects – Finnish and 3 optional subjects. In 2017-18, only 24 students (20%) were selected based on the suitability test alone, and 96 students (80%) based on the suitability test and the grades in the YLIO in Finnish and mathematics. Thus, the number of students at HEL who took a mathematics test in the YLIO increased by at least 20 percentage points.

In Spain, primary teachers are required to have completed a Degree in Primary Teaching (240 ECTS). Access to primary teaching degrees can be gained via the Baccalaureate (2 years of non-compulsory education) or through a vocationally-oriented Professional Cycle. Those who study Baccalaureate may choose a track containing mathematics – either mathematics or mathematics for social sciences – but some tracks do not contain any mathematics subjects. The professional cycles from which students gain access to the primary teaching programs do not have mathematics courses. Those that have completed the baccalaureate have to pass the *Pruebas de Acceso a la Universidad* (henceforth PAU) to be admitted to any university program. Four of the exam papers of the PAU are universal for all students across Spain, but this is not the case for mathematics, which is an optional subject. Students who have completed a Professional Cycle may also gain access to university. Therefore, applicants to teacher education programs in Spain will not have taken any mathematics courses in post-compulsory education unless they have taken one of the two tracks of the Baccalaureate that include mathematics. It is important to point out that the number of student places in primary teaching degrees in Spain bears no relationship to the actual number of teaching jobs in the market. At BCN, around two thirds of the applicants were admitted for the academic years 2016-17 and 2017-18[1]. In the academic year 2016-17, there was no specific requirement for admission to Primary Teaching programs in Spain outside the universal procedure described above. However, in Catalonia, starting in the 2017-2018 academic year, a specific complementary entrance examination – which includes a mathematics test – was implemented.

[1] http://universitats.gencat.cat/ca/altres_pagines/informe_i_estadistiques/informes_i_estad_pre/

Data collection

Instrument

The instrument we used to collect our data was the mathematics test that had been designed and used to pilot the specific complementary entrance examination in Catalonia mentioned above that had the administrative purpose of regulating access to primary teaching degrees in Catalan universities. The mathematics test was intended to ensure a minimum mathematical content knowledge of admitted candidates (for a detailed description of how the test was created and validated see Albarracín et al., 2018). The test evaluated disciplinary knowledge of a conceptual and procedural nature.

The test had 25 questions, with an open-answer format, related to the prescribed curriculum of Spanish compulsory education – Numbers and Arithmetic, Space and Shape, Relations and Change, Magnitude and Measure, and Statistics and Randomness. The weight given to each content area was related to the actual presence of said contents in the school practice. Thus, there were 7 items on numbers and arithmetic (procedural and conceptual exercises with natural, integer, fraction and decimal numbers), 5 items on magnitude and measure (concepts of length and area, calculation of perimeter and area, and units change, in both decimal and sexagesimal systems), 5 items on relations and change (3 items on proportionality, 1 patterns, and 1 graph interpretation), 4 items on space and shape (2 conceptual on plane geometry, 1 visualization, 1 representation) and 4 items on statistics (1 reading and 1 construction of bar charts, 1 interpretation of a pie chart, all of them procedural, and 1 on conceptual measures of central tendency). Students had 90 minutes to answer the test and no calculators were allowed.

The following are examples of the items in the test:

- *4- A product is on sale. According to the label, the normal Price is £125. The sale price is £100. What percentage of discount has been applied?*
- *7- Which prime number can be made by subtracting two multiples of 7?*
- *14- What is the surface area of a square with a permiter of 32 cm?*
- *16- Which of the following figures must have equal diagonals? a) square; b) rhombus; c) rectangle; d) trapezium*
- *18- How many cm are in 7.8 km?*
- *24- What number would we add to the list in order for the mean to equal 7? {2, 6, 6, 6, 8, 8, 9}*

From the beginning we were aware that the test, as it had been defined, was going to be culturally context-bound to the idiosyncrasies of the educational system in which it had arisen. Although the curricula in Finland and Spain are not so different, the emphasis placed on each of the subjects and the way they are taught in class is. We have purposely included some of the items of the questionnaire as examples that will serve to illustrate how the questionnaire was bound to the context. For example, it was already expected that item 7 shown above would harm students' results in HEL, since, although they work on divisibility, the term "prime number" is not as familiar to them. Another example would be item 16 since it includes the idea of a rhombus, which is rarely used in Finland – it is not a category in itself in the classification of quadrilaterals that

schoolchildren learn, contrary to what happens in Spanish school mathematics lessons, where the rhombus gives rise to a category in itself. A full discussion of how the test was context-bound can be found in Albarracín et al. (2018).

Participants and data collection

In HEL, the test was taken by the 116 students starting their primary teaching education program in 2016-17 and 2017-18, at the very beginning of their courses in August. In BCN, the 254 students that initiated their teaching education in 2016-17, and the 276 that did so in 2017-18, took their test in February, at the beginning of the second semester. Neither in HEL nor in BCN had students taken any university class on mathematics or mathematics education at the time of the test.

Students had to answer the test on a worksheet, without using a calculator and in a maximum time of 90 minutes. The answers were marked, assigning 1 point when the answer was completely correct (meanings, calculations, units, etc.) and 0 points if it was not. The students' grades in the exam are part of our data, the other group being the information they gave us about their previous academic trajectory, allowing us to gain information on which (if any) mathematics courses they had taken as part of their pre-university education.

Results

Reliability of the instrument

First, to test the reliability of the data obtained in the test, we calculated the Cronbach's alpha, both overall and for each campus, as an internal consistency estimate of the reliability of the test scores. The results that we obtained (α BCN·16·17 = 0.8157; α HEL·16·17 = 0.8106; α BCN·17·18 = 0.7963; α HEL·17·18 = 0.7579; α Overall = 0.7985), in all cases higher than the reference value of 0.7, were a suitable indicator of the internal consistency of the instrument, meaning that the different questions of the test evaluate the mathematical knowledge with which students arrive at the teacher education programs, in a coherent way and from a disciplinary perspective. In this way, we consider that the instrument sufficiently and consistently approaches our idea of background mathematical knowledge.

Differences in performance

Table 1 presents the basic statistics that describe the centrality and distribution of the scores in the test by the students in HEL and BCN in 2016-17 and 2017-18 academic years.

Variable	HEL·16·17	HEL·17·18	BCN·16·17	BCN·17·18
N	116	116	254	276
Mean	17.233	17.595	15.996	17.750
SE Mean	0.405	0.368	0.302	0.264
StDev	4.363	3.963	4.812	4.389
Minimum	7.000	6.000	3.000	4.000
Q1	14.000	15.000	12.000	15.000

Median	17.500	18.000	16.000	18.000
Q3	21.000	21.000	20.000	21.000
Maximum	25.000	24.000	25.000	25.000

Table 1: Centrality and distribution of marks

A series of mean comparison t-tests allows us to establish the significance of differences (Table 2)

	Estimate for Difference	Confidence Interval for difference (95%)	p-value
HEL·17·18 vs. HEL·16·17	0.362	(-0.716; 1.440)	0.509
BCN·17·18 vs. BCN·16·17	1.754	(2.539; 0.969)	0.000
HEL·16·17 vs. BCN·16·17	1.237	(0.242; 2.232)	0.015
HEL·17·18 vs. BCN·17·18	-0.155	(-1.084; 0.773)	0.743

Table 2: T- tests comparison of score means across universities

As can be seen in Table 2 for 2016-17, students at HEL obtained significantly better results than students at BCN. It also shows that at HEL there was no significant change in performance between 2016-17 and 2017-18. However, results at BCN were significantly better in 2017-18, to the extent that such results cannot be statistically distinguished from the results in HEL of the same year.

Impact on the academic profile of students admitted to BCN

We note that there are only significant differences between the results before and after the implementation of a new requirement at BCN, this being the only change affecting entry conditions at BCN. In Albarracín et al. (2018) we had found that the academic profile of students prior to entering university generated different results. Therefore, it is interesting to explore what aspects have changed in the profile of admitted students – we have no information about those who applied for admission but were not admitted.

We labelled BCN students who had only taken the compulsory mathematics BCN·COM and those who had followed the Baccalaureate track containing mathematics BCN·BAC. Table 3 shows the proportion of students and the mean of the scores obtained in the test by the students in each subgroup, as well as the standard deviations. Table 4 shows the results of the T-tests comparing the mean scores of the subgroups.

	Percentage of students in each subgroup	Mean score (max. 25)	Standard deviation
BCN·COM·16·17	42.52%	13.611	4.488
BCN·BAC·16·17	57.48%	17.760	4.263

BCN·COM·17·18	32.61%	15.967	4.348
BCN·BAC·17·18	67.39%	18.613	4.153

Table 3: Proportion of students that had taken mathematics after compulsory education, and the mean scores of each subgroup, with standard deviations

	Estimate for difference	Confidence interval for difference (95%)	p-value
BCN·COM·16·17 vs. BCN·BAC·16·17	-4.033	(-5.175; -2.891)	0.000
BCN·COM·17·18 vs. BCN·BAC·17·18	-2,646	(-1.580; -3.712)	0.000
BCN·COM.1718· vs. BCN.COM.1617	2.356	(3.601; 1.110)	0.000
BCN.BAC.1718 vs. BCN.BAC.1617	0.853	(1.766; -0.061)	0.067

Table 4: Results of the T-tests comparing the mean scores of the subgroups depending on whether they had taken mathematics after compulsory school

In both the 2016-17 and 2017-18 academic years, students who had studied mathematics during Baccalaureate obtained better test results than those who had not. In addition, the 2017-18 academic year increased the number of students in the first group by 10 percentage points. In the 2017-18 academic year, students who had studied mathematics during Baccalaureate obtained better results than the same group in the previous academic year, but by a few thousandths we cannot say that this difference is significant. However, the difference is significant between 2016-17 and 2017-18 for those who had not studied mathematics during their post-compulsory education.

Discussion

In our contribution we analyzed the impact of changing the criteria and requirements for admission to the teacher education programs of the Universitat Autònoma de Barcelona and the University of Helsinki. In both cases, the change implies a greater demand in relation to mathematics. However, we see that while in Barcelona the impact is significant, in Helsinki it is not so.

The results from BCN show that the introduction of the mandatory requirement to pass a mathematics test in order to gain access to the teachers' education program has generated a change in the academic profile of admitted students and their mathematical background knowledge has improved significantly compared to the previous academic year. We found that the number of students who continued to study mathematics after completing their compulsory schooling has increased by 10 percentage points. Our knowledge of the Catalan university system allows us to state that the only variable that could have generated this change in the academic profile of the students is the introduction of this new requisite. In addition, those who dropped out of mathematics at the end of compulsory schooling have also proven to have a better background mathematical knowledge than those in the same group the previous year. From informal conversations with the

students, we dare to say that they have prepared for the new specific mathematics test that was part of the new entrance requirements.

However, we did not observe any significant changes in Helsinki. We believe that this is essentially due to the fact that the instrument used to collect our data was bound to the Catalan context. Although access to the primary teaching program in Helsinki had increased its mathematical demands, the terminology and formalism of the test that we used are still elements that have little weight on the education of Finnish students. In Hel, the new entrance requirement implies that a greater number of admitted students have studied secondary mathematics. However, the mathematics of intermediate or advanced courses of upper-secondary in Finland are of little help to answer test questions linked to an approach that is characteristic of another national context.

We find it interesting to compare data from two cultural realities as different as the university systems of Finland and Catalonia. These results provide us with ideas that a study restricted to only one country would not generate, and these ideas can contribute to decision making. In particular, the changes introduced in Helsinki in the 2017-18 academic year are a consequence of the analysis of the results obtained by its students in the 2016-17 academic year. In Catalonia, our study can help to support the changes introduced that are beginning to be questioned by the media. We plan to incorporate data from other European universities into our study in the near future.

We are aware that working with a context-bound data collection instrument generates dilemmas, such as those suggested by Clarke (2013), that appear when an international comparative study is carried out. In spite of this, researchers working together who are outsiders with respect to each other's data, cultural contexts and national realities leads to richer and more nuanced interpretations. In addition, working with a context-bound instrument, while it makes comparison difficult, directs the researchers' attention to the need for an in-depth theoretical discussion about what the desirable mathematical knowledge would be for candidates to initial teacher education programs. An agreement on the theoretical level on what basic knowledge an entrance examination should evaluate would help to agree on the characteristics of the examination on the methodological level, to avoid it being strictly tied to a context.

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