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Education and Cognitive Skills in the Spanish Adult Population Inter-generational Comparison of Mathematical Knowledge from the PIAAC Data

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INTRODUCTION

Background

The *Programme for the International Assessment of Adult Competences* (PIAAC), coordinated by the OECD, is a new step in the generation of internationally comparable data on the cognitive skills of the population in a wide range of countries. It extends former work on the abilities of the adult population in the field of reading literacy (IALS, ALL) and complements the studies carried out on the levels of competence of young people in different fields and for different ages (PISA, PIRLS and TIMSS, among others).[1] The present study provides cross-section data on the skills of the adult population (aged 16 to 65 years) in the areas of *reading literacy* and *mathematics.* Twenty-four countries have participated in this first wave and a few more will be incorporated in an extension intended for the next years. The assessment of people's skills is carried out through questionnaires and the valuations are measured on a scale of 0-500 points.

The key aim of this new database is that of enabling a better understanding of the relationship between education, acquisition of cognitive skills and the ageing of the population. Those are relevant aspects for personal fulfilment, the accumulation of human capital, the dynamics of the job market, and the development of societies. This study expands substantially the available evidence on those matters and will thus facilitate the design of effective policies to enhance people's skills and to support their development and implementation in different countries (see OECD (2012, 2013) for a discussion).

There is broad range of empirical evidence that shows that investing in expanding the skills of the population is the best recipe for transforming scientific and technological development into growth and welfare (see for example, Acemoglu & Robinson (2012)). The acquisition of those skills is closely linked to both formal education and experience (Desjardins (2003), Statistics Canada & OECD (2000), (2005)). For this reason, the provision of formal education and a suitable integration into the labour market are key for the development of people's skills. One has to bear in mind that the worth of those skills tends to decrease over time, their under-utilization or their lack of use, and the mismatch that may derive from changes into the individuals' environment (Pazy (2004), Staff et al. (2004), De Grip et al. (2005)).

[1] *IALS: International Adult Literacy Survey. ALL: Adult Literacy and Lifeskills Survey. PISA: Program for International Student Assessment. PIRLS: Progress in International Reading Literacy Study. TIMSS: Trends in International Mathematics and Science Study. The first three studies are coordinated by the OECD whereas the last two by the International Association for the Evaluation of Educational Achievement.*

Cognitive Skills, Aging of the population and Demographic Structure

There is a well-defined pattern of the evolution of cognitive skills. Theoretical and empirical studies show that there is a negative correlation between cognitive skills and age. This phenomenon, which is observed in cross-section and longitudinal studies, is compatible with the existence of different pathways, depending on the type of the cognitive skill being considered. All cognitive skills seem to increase up to the ages of 18 or 20 years; soon after the decay starts in some types of cognitive skills while others decrease later on. Be as it may, they always end up by diminishing at older ages (see Desjardins & Warnke (2012) for a fuller discussion).

The dynamics of the cognitive skills are very complex because they involve individual and social aspects. The individual aspects are associated with processes of neuronal and behavioural maturation (the latter resulting from the accumulation of knowledge, the effect of use –experience- and from the individual's interaction with a changing environment throughout his/her life). There are also changes in the social context that affect in different ways the experience of the cohorts present at any given point in time (the so-called *cohort effects* and *period effects*).[2] All of this may alter the pattern of individual and collective interactions associated with the evolution of cognitive skills.

As a result, the analysis of the relationship between cognitive skills and demographic structure turns out to be complex, especially as there is a wide range of cognitive skills whose patterns of behaviour differ over time (e.g. *fluid* skills vs *crystallized* skills, *basic* skills versus *fundamental* skills). In particular, cross-section studies must be interpreted carefully because of the ageing effect being mixed up with cohort effects that can be important.[3] Such studies, however, are suitable for analyzing the differences that exist between individuals of different ages at a point in time and they are relevant from the perspective of public action (see Schaie (1996), (2009)).

The study of the cognitive skills across generations in a given country is particularly important right now for several reasons. Firstly, because of the effect of the economic recession that has generated levels of unemployment unknown for decades, especially among the young, which leads to a very rapid loss of the educational investment. Secondly, because of the progressive ageing of the working population associated with an increase of life expectancy and the delay in the retirement age. And thirdly, because of the impact of human capital endowments on the distribution of income and employment.

Aim of the Study

In this study we analyse the results of the PIAAC tests for Spain in the field of *mathematical competence*, by comparing the relative worth of the skills acquired by the different generations that compose the Spanish working age population.

Although the PIAAC data refer to both reading literacy and mathematics, we have chosen the mathematical competence because it is perhaps the most relevant novelty of that study, since there were already different assessments of adults' reading competence (e.g. IALS and ALL). It

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[2] Cohort effects are related to some structural changes that affect the development of cognitive skills of some cohorts in relation to others (eg: the extension of compulsory education). Period effects refer to events that occur at a certain point in time and affect all cohorts simultaneously.

[3] Desjardins & Warnke (2012) propose the use of sequences of cross-section studies as the best alternative, given the scarcity and small size of the samples of the available longitudinal studies. In their study they carry out an exercise comparing results of IALS and ALL for a set of nine countries, with the aim of later incorporating those from PIAAC. Unfortunately Spain did not participate in the earlier IALS and ALL studies, so that this strategy of analysis is not available for our country.

is also a type of cognitive skill in which the effect of ageing might be more significant, since some of the language skills seem to increase through use and context up to relatively advanced ages.
Mathematical competence is defined as the ability "to access, use, interpret and communicate mathematical information and ideas in order to relate and manage mathematical situations found in adult life. This involves managing situations or resolving problems in real contexts, responding to ideas, information or mathematical content represented in different ways."

PIAAC defines six ***levels of competence***, parameterized by certain thresholds of the test scores. Table 1 shows those thresholds and describes the elements that characterise each level. Note that the setting of the levels is essentially qualitative (i.e. the levels are defined in terms of the tasks that individuals are able to perform) and then it is made operational through a convenient parameterization.

Table 1: Description of performance levels in mathematics with corresponding score intervals

Level	Types of tasks successfully completed in each performance level
Below level 1 ***Less than 176***	Tasks at this level require the interviewee to perform simple processes such as counting, sorting, performing basic arithmetic operations with whole numbers or money, or to recognize common spatial representations in specific and familiar contexts where the mathematical content appears explicitly with little or no text or distractors.
1 ***176 – 225***	Most of the tasks in this level require the interviewee to perform basic mathematical processes in common and specific contexts in which the mathematical content appears explicitly with little text or distractors. The tasks to be performed usually require simple processes such as counting, sorting, performing basic arithmetic, understanding simple percentages like 50%, and locating and identifying elements or simple spatial or graphic representations.
2 ***226 – 275***	At this level the interviewee is required to identify and manage information and mathematical ideas within a range of common contexts in which the mathematical content is visually or explicitly presented with relatively few distractors. The tasks usually require the application of two or more steps or processes that involve calculation of decimals with one or two figures, percentages and fractions; simple measurements and spatial representation; estimation; and interpretation of data and relatively simple statistics in texts, tables and graphs.
3 ***276 – 325***	The interviewee is required, at this level, to understand a wide range of mathematical information that may be complex, abstract, or may be found within unfamiliar contexts. These tasks require several steps and may involve problem-solving strategies and relevant processes. Tasks will include the application of the concepts of number and spatial sense; recognition and work with mathematical relations, patterns, and numerically and verbally expressed proportions; and the interpretation and analysis of basic data and statistics in text, tables and graphs.
4 ***326 – 375***	At this level the interviewee must understand a wide range of mathematical information that may be complex, abstract or be included in unfamiliar contexts. For these tasks it is necessary to perform multiple steps and choose relevant processes and strategies of problem solving. The tasks tend to require a more complex level of analysis and reasoning about quantities and data; statistics and probability; spatial relations; and change, proportions and formulas. At this level it may be necessary to understand formulations or formulate explanations for the answers or choices.
5 ***376 – 500***	Tasks in this level require the interviewee to understand complex mathematical representations and ideas as well as abstract and formal statistics, possibly included in complex texts. Interviewees may possibly have to integrate multiple types of mathematical information which require translation and interpretation; draw inferences; develop or work with mathematical models or arguments; and justify, evaluate and critically reflect on solutions or choices.

Source: PIACC (2012)

Our goal here is to carry out an intergenerational comparison of cognitive skills of the Spanish adult population in the field of mathematics. The main novelty of our analysis, besides the database, is the use of the complete distributions of the population of the different cohorts in the five levels of competence defined above. Our approach involves, therefore, going beyond the comparison of mean values and exploiting the information contained in the simplified version of the density provided by the distribution the cohorts through competence levels. To do so we apply the methodology of Herrero & Villar (2013), which allows the comparison of categorical variables between different population groups. The evaluation of a group is a measure of the probability that this group "dominates" other groups, in the sense that an individual picked at random from this group will have a level of competence above an individual randomly selected from any other group. We describe the evaluation procedure in Section 2. We shall see that the evaluation so obtained differs substantially from the comparison of the average values of the test.

Each cohort will be divided into three groups according to their educational achievements (compulsory education, secondary education and university studies), in order to perform the comparative analysis. We shall use the term "educational achievements", instead of the more usual "education levels", in order to preserve the term *level* for the six "competence levels" in Table 1 and so avoid confusion.

THE EVALUATION PROCEDURE

We address the comparison of the cognitive skills of the different cohorts using the model developed in Herrero & Villar (2013) for the relative evaluation of groups in terms of categorical variables. That approach is related to the statistical analysis of similarity between orderings and to the sociological and economic literature regarding comparative assessments in different contexts (e.g. Lieberson (1976), Reardon & Firebaugh (2002), Laslier (1997), Palacios -Huerta & Volij (2004)).

We focus on the Spanish working age population, which will be divided into five different cohorts. Each cohort is then sub-divided into three different sets, according to the educational achievements of its components. From this configuration we will analyze the distribution of each of the resulting groups (defined by cohort and educational achievement) in terms of the *five* competence levels defined by PIAAC.[4]

The Evaluation Model

The basic idea is as follows. We have a population divided into a set of g groups (the fifteen resulting from five cohorts and three educational achievements, in our case). The individuals' outcomes (PIAAC test results) can be classified into s categories (five competence levels), ordered from best to worst. Let a_{ir}, $i = 1, 2, \ldots, g$, $r = 1, 2, \ldots, s$, denote the share of individuals in group i in the r category.

We say that group i ***dominates*** group j when it is more likely that picking at random an individual from group i she belongs to a higher category than that of another individual randomly chosen from group j. The probability that an individual from group i dominates another from group j, p_{ij},, is calculated as follows:

$$p_{ij} = a_{i1}(a_{j2} + \ldots + a_{js}) + a_{i2}(a_{j3} + \ldots + a_{js}) + \ldots + a_{i,s-1}a_{js} \qquad [1]$$

From here we can define the relative advantage of group i with respect to group j, RA_{ij}, as follows:

$$RA_{ij} = \frac{p_{ij}}{\sum_{k \neq i} p_{ki}}$$

[4] PIAAC actually defines six levels, from below 1 up to 5; yet there is in only one entry in level 5 with too few observations so we have aggregated levels 4 and 5 without loss of generality.

The relative advantage of group *i* with respect to group *j* is nothing more than the probability that group *i* dominates group *j* divided by the sum of the probabilities that group *i* be dominated by some other group.

To obtain an overall evaluation of group *i* in society, we take a weighted sum of its relative advantages with respect to all other groups. That is, the relative advantage of the group *i* is given by:

$$v_i = \sum_{j \neq i} \lambda_j RA_{ij}$$

Since the weights λ_j reflect the relevance of the different groups, it is only natural to choose them consistently with their own evaluation, i.e. taking $\lambda_j = v_j$. In this way, each group enters the evaluation of the relative advantage of the others with the weight corresponding to its own relative advantage. This implies that we have to find a vector $\mathbf{v} = (v_1, v_2, \ldots, v_g) > \mathbf{0}$ such that:

$$v_i = \sum_{j \neq i} v_j RA_{ij} = \frac{\sum_{j \neq i} v_j p_{ij}}{\sum_{k \neq i} p_{ki}}, \quad i = 1, 2, \ldots, g \ [2]$$

Herrero & Villar (2012) prove that this vector always exists, is strictly positive and unique (once normalized) and that it can be easily calculated since it corresponds to the dominant eigenvector of the following matrix:

$$Q = \begin{bmatrix} g-1-\sum_{i \neq 1} p_{i1} & p_{12} & \cdots & p_{1g} \\ p_{21} & g-1-\sum_{i \neq 2} p_{i2} & \cdots & p_{2g} \\ \cdots & \cdots & \cdots & \cdots \\ p_{g1} & p_{g2} & \cdots & g-1-\sum_{i \neq g} p_{ig} \end{bmatrix} \ [3]$$

The off-diagonal elements of the *Q* matrix are the pair-wise dominance probabilities p_{ij}. The elements on the diagonal tell us the probability that a randomly chosen individual from group i belongs to a category that is not worse than a randomly chosen individual from any other group. Is easy to see that the matrix *Q* is a Perron matrix whose columns add up to (g - 1). From this it follows (see for instance Berman & Plemmons (1994)) the existence, positivity and uniqueness (when *Q* is irreducible) of the **v** vector whose components satisfy equation [2].

Application to Our Problem

The problem that we want to address here is the comparative evaluation of human capital accumulated by the different cohorts, in the field of mathematics. For this we are going to use the information on the distribution of PIAAC test results for each cohort and educational achievement in the five competence levels defined. Our reference groups will, therefore, be different ***cohorts by educational achievement***. We have considered five cohorts: population of 24 years old or less, population between 25 and 34 years old, population between 35 and 44 years old, population between 45 and 54 years old, and population of 55 years old or more. And three educational achievements: compulsory education, secondary education, and university studies.[5] The categories correspond to the above-mentioned five competence levels: below 1, 1, 2, 3 and 4 plus 5.

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[5] As the study refers to a set of generations that have experienced diverse educational systems, it should be clarified that by compulsory education we mean those individuals who have achieved, at most, the equivalent of the current compulsory education (up to age 16). We include in secondary studies all those who have reached the current level of baccalaureate (or equivalent professional training). In university

Thus, we will have a Q matrix (as in equation [3]) of 15 by 15 entries, which generates an eigenvector of fifteen components. This eigenvector provides an estimate of the relative quality of the human capital in the different cohorts in the field of mathematical competence, where each cohort with a given educational achievement is compared with all the other cohorts with their corresponding educational achievements. Since the eigenvectors have a degree of freedom, we will choose the normalization that makes the first component of the eigenvector equal to one. We measure, therefore, the value of each cohort in terms of the value that it represents over the youngest cohort with the lowest educational achievement. We will refer to this context as ***the joint evaluation.***

From this joint evaluation we will carry out two additional assessment exercises. First, trying to identify the intergenerational profile of those cohorts with the same educational achievements. Second, trying to isolate the impact of intermediate and higher education on the evaluation of each cohort.

To analyse the impact of ageing on cognitive skills, we re-normalize the values of the eigenvector by making the worth of the youngest cohort for each educational achievement equal to one. The resulting values provide a measure of the quality of human capital of each cohort relative to the other cohorts with the same education, in units corresponding to the value of the youngest generation. We will refer to this context as a ***separate evaluation by educational achievements***.

To analyse the impact of secondary and university education on the evaluation of the different cohorts, we will compare groups of the same age, making the value of all the cohorts with compulsory education equal to one. In this way we compare the variation of the quality of human capital due to the increase in education, in terms of the value of compulsory formation for each age group. We will refer to this context as the ***separate evaluation by age***.

RESULTS

Population Distribution by Competence Levels and Joint Assessment of The Cohorts by Educational Achievements

Table 2 provides complete information on the distribution of cohorts in the different levels of mathematical competence, according to their educational achievements. This is the basic information for constructing the Q matrix of equation [3] according to the formula [1].

Table 2: Distribution of the different cohorts in the five competence levels by educational achievements (%)

Cohorts	Competence leves (mathematics)					
	4	3	2	1	< 1	Accummulated
Compulsory education						
24 or less	0.29	18.62	50.53	23.01	7.56	100
25-34	1.25	13.42	43.08	28.51	13.74	100
35-44	0.23	10.85	48.66	28.18	12.08	100
45-54	0.31	7.52	39.66	35.67	16.85	100
55 or more	0.00	3.74	30.41	36.34	29.50	100

education we include both the individuals who have done a five year degree (long cycle), a three year degree (short cycle) or the most recent of four years, as well as the equivalent professional training.

Secondary education						
24 or less	3.85	41.36	45.13	8.68	0.98	100
25-34	2.91	32.25	47.09	16.43	1.31	100
35-44	2.45	35.25	44.28	14.83	3.19	100
45-54	2.87	22.98	56.91	14.64	2.60	100
55 or more	1.35	14.84	56.61	23.53	3.67	100
University studies						
24 or less	16.30	41.24	40.95	0.19	1.33	100
25-34	11.82	50.73	34.05	3.40	0.00	100
35-44	10.01	54.55	31.67	2.64	1.13	100
45-54	12.56	47.53	32.19	6.36	0.98	100
55 or more	5.30	35.31	44.23	14.72	0.44	100

NB: The data on each cohort by educational achievement is obtained by elevating the sample data to the level of the population, using the corresponding elevation coefficients.

The data show that the larger proportion of the population with compulsory education lies in competence level 2, except for the oldest cohort in which most have level 1. There is a broad representation of the population with this education below level 1, especially for the oldest cohorts, while there is practically no participation at level 4. The larger fraction of the population with secondary studies is also situated at level 2, but now there is a significant part of the population in level 3, more so the younger the cohort is. Level below 1 is almost empty in all age groups and level 1 is not very important, except for the oldest population. Finally, in the population with university education level 3 clearly prevails, except for the cohort of 55 or more where level 2 is majoritarian. Level 1 is not very important, except for the oldest cohort, while level 4 has a broad representation, especially in the younger cohorts.

From a formal point of view getting an evaluation of the different cohorts amounts to transforming the matrix of 75 values in Table 2 into a vector of fifteen components that describes the relative position of each group according to the domination probabilities. This form of valuation of the groups takes into account the distributions at different competence levels of the individuals, depending on the cohort they belong to and on the educational achievement

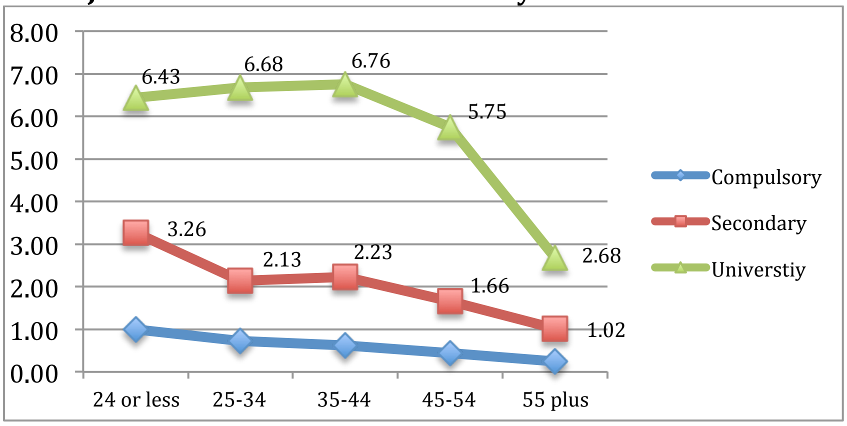
The resulting evaluation provides a measure of the relative quality of human capital in the field of mathematical competence. To properly interpret the results presented below we should bear in mind that we have normalized this measure so that the value of the youngest cohort with the lowest education is equal one. Therefore, each value is expressed in this type of units.

The results of the joint evaluation of the different cohorts by educational achievements, Figure 1 and Table 3 (A), show that:

- Within each cohort the group with university studies has a much higher value than that with secondary studies, and the latter has a value clearly higher than the group with compulsory studies.
- The groups with university studies dominate all the others, except the oldest group with respect to the younger group with secondary studies.
- The values tend to decrease with age for all educational achievements. The difference between the youngest cohort and the oldest is very large, but the reduction path is not uniform.
    - The joint evaluation of the groups with compulsory education shows a moderate reduction, steadily decreasing with age.

- The joint evaluation of the groups with secondary education drops substantially from the first to the second cohort before slightly recovering and then dropping moderately.
- The joint evaluation of the groups with university studies presents a profile slightly increasing for the first three cohorts, dropping noticeably in the fourth and very prominently in the last.

Figure 1- Joint evaluation of the cohorts by educational achievements



This evaluation of the cohorts differs clearly, regarding the relative magnitudes, from the one that would be obtained by associating the average value of the PIAAC tests to each cohort and educational achievement. Table 3 (B) sufficiently illustrates this difference (in it we have also normalized the average values by setting equal to one the average of the youngest cohort with lower education, in order to be able to make the comparison).

Table 3: Valuation of the cohorts according to formative stages and average values (normalized) of the tests

Education	Cohorts				
	24 or less	25-34	35-44	45-54	55-65
(A) Joint Valuation					
Compulsory	1.00	0.73	0.62	0.44	0.24
Secondary	3.26	2.13	2.23	1.66	1.02
University	6.43	6.68	6.76	5.75	2.68
(B) Normalized average values					
Compulsory	1.00	0.95	0.95	0.90	0.84
Secondary	1.12	1.09	1.08	1.06	1.02
University	1.19	1.19	1.20	1.18	1.11

Comparison of the Cohorts by Educational Achievements: Separate Evaluation by Educational Achievements and Separate Evaluation by Age

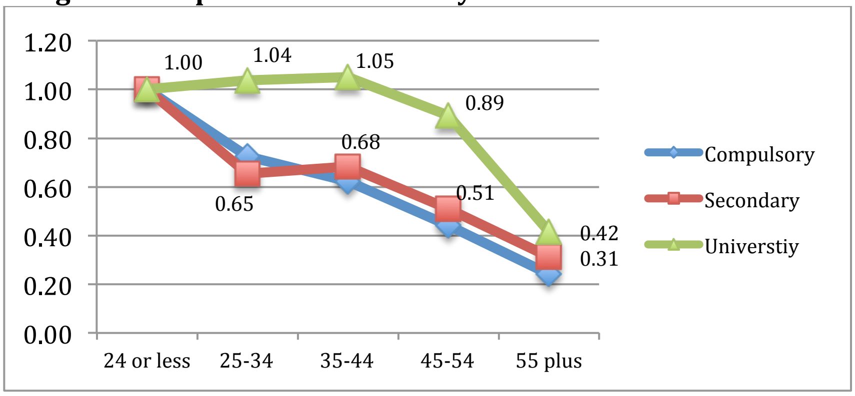
The joint evaluation presented in the previous section combines the effect of ageing and the effect of education. The separate evaluations that follow attempt to assess the importance of each one of these effects.

To carry out the ***separate evaluation by educational achievements*** (Figure 2 and Table 4 (A)), we make the value of the youngest cohort equal to one for each educational achievement. In this way we get an estimate of "the cost of ageing" in terms of cognitive skills, depending on the education. The data show a similar pattern in the population with compulsory and secondary education. On the one hand, the worth of the youngest cohort is well above the others. On the other hand, there is a very sharp drop in the worth of the second cohort with respect to the youngest one. This effect is corrected slightly in the third cohort for the case of secondary education, and then continues to fall sharply in the fourth and fifth cohorts.

The evaluation of the cohorts with university studies shows a different profile. Their worth increases for the first three cohorts, slightly decreases for the fourth one and then drops sharply for the oldest cohort. In addition, the dispersion of the values of the population with university studies is much lower than that of the rest.[6]

The loss of value of human capital between the youngest generation and the oldest one oscillates between 75% for the population with compulsory studies and 60% for the population with university studies. The relatively small difference of this depreciation between the cohorts is largely related to the sharp drop in the value of the older population with university studies.

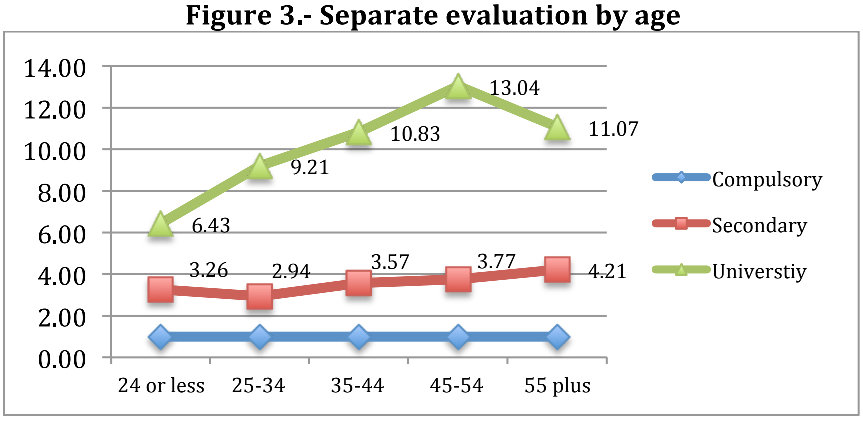
Figure 2.- Separate evaluation by educational achievements



We now consider the ***separate evaluation by age*** in order to get an idea of the effect of education on each cohort. In this case we make the value of each cohort with compulsory education equal to one.

The data show that reaching secondary education translates to a value of between three and four times that of the compulsory education of each cohort, with an increasing impact with age (Figure 3, Table 4 (B)). This figure rises to values between six and a half and thirteen times in the case of university studies, with an increasing pattern until the fourth cohort before falling in the final one.[7] The graphic illustrates well that educational achievements substantially affect cognitive skills across generations.

Figure 3.- Separate evaluation by age



[6] The coefficient of variation is 0.46 for the case of compulsory education, 0.41 for secondary education and 0.29 for university studies.

[7] The values of the ratios between university and intermediate education, from the youngest generation to the oldest, are the following: (1.97); (3.13); (3.04); (3.46); y (2.63).

Table 4: Separate evaluation of the cohorts by educational achievements and by age

Education	Cohorts				
	24 or less	25-34	35-44	45-54	55-65
(A) Separate evaluation by educational achievements					
Compulsory	1.00	0.73	0.62	0.44	0.24
Secondary	1.00	0.65	0.68	0.51	0.31
University	1.00	1.04	1.05	0.89	0.42
(B) Separate evaluation by age					
Compulsory	1.00	1.00	1.00	1.00	1.00
Secondary	3.26	2.94	3.57	3.77	4.21
University	6.43	9.21	10.83	13.04	11.07

DISCUSSION

Introduction

One of the most fundamental changes experienced by the Spanish society in the last decades has been the increase of the educational achievements. The average years of schooling of the Spanish population has been substantially enlarged due to three main causes. First, the extension of compulsory education from fourteen to sixteen years.[8] This implies that the population with "compulsory education or less" has a different composition in the younger and the older cohorts. Second, the wide proportion of children nowadays receiving early education (pre-schooling). There is evidence of the important role that early education has in the acquisition of cognitive skills in adulthood. And third, the expansion of non-compulsory education (particularly with respect to university studies). All those elements create a cumulative effect that modifies the composition of the different cohorts regarding educational achievements, by improving the relative situation of the younger cohorts with respect to the older ones.

There are also some cohort-specific effects due to the institutional features of the education system and the labour market. Those "cohort effects" affect the dynamics of cognitive skills by interacting with the effect of education and ageing. Regarding the educational system, there has been a number of changes in the structure of the studies, whose implementation may involve costs for those who experience them (e.g. the LOGSE or the adaptation of the university studies to the European Space of Higher Education). As for the labour market, there are relevant differences in the probability of getting a permanent job between the different cohorts, due to the institutional design of the Spanish labour market. Young people exhibit much lower rates of stable jobs than older people, a feature that affects the decay of cognitive skills.

The presence of those cohort effects entails that we find differences in the groups even when we homogenize them by educational achievements or by age. As our model is mostly descriptive, the ensuing discussion is to be regarded as a guide to identify possible effects, to be later analysed in magnitude and relevance by more specific econometric studies (see Robles (2013) for an analysis of this type).

[8] This change was introduced when the "Ley General de Educación" was substituted by the "Ley Orgánica de Ordenación del Sistema Educativo (LOGSE)", formally sanctioned in 1990.

Differences by Educational Achievements: The Impact of Aging

In agreement with the predictions of the generally accepted theory and the available evidence, the data from this study show a clear process of depreciation of cognitive skills due to the effect of ageing. Such a tendency is accentuated by the expansion of the years of schooling in the younger generations. This common pattern, though, is compatible with differentiated profiles by educational achievements.[9]

We have seen that the evaluation of youngest cohorts with compulsory and secondary education is well above the others, and that there is a substantial reduction between the first and second cohorts (with a slight correction in the third cohort in the case of secondary education, before dropping again in the fourth and fifth cohorts in both formative grades). The population with a university studies shows a different profile, with increasing values until the third cohort and a significant drop in the last.

In order to understand the sharp drop in the evaluation of the second cohort with respect to the first, for the population with secondary and compulsory studies (a 35% reduction in one case and 27% in the other), and the different behaviour of those with university studies (a 4% increase), we should take into account three aspects that work in a complementary way. Firstly, the number of years elapsed since the individuals quit studying up to the moment in which the surveys were carried out (worse results as more time elapsed). In the case of the population with compulsory education that had finished studying at the time of the survey this time span is a minimum of nine years (six in the case of secondary education), while in the case of university education it can be one or two years.[10] Moreover, some 60% of the population with compulsory education and 65% of the population with secondary education from the first cohort, were actually still studying (something which tends to improve the results obtained by the younger generation with respect to the next because of keeping active the process of formal learning). Secondly, there is an effect induced by the labour market that can also help explaining the sharp drop of the evaluation between the first and the second cohorts. Unemployment rates are particularly high in the youngest cohort during the last years. This implies that, even though the situation is better for the second cohort, those individuals between 25 and 34 have already experienced long periods of unemployment (see Table 5), which entails a faster depreciation of human capital in those groups (the "use it or lose it" hypothesis of Mincer & Ofek (1982)). Finally, the data also suggest the presence of quality changes in the education of the different cohorts. The outcomes might be showing the so called "LOGSE effect", i.e. the negative impact of the changes introduced by that law, which would have had a larger incidence on the population with compulsory and secondary education (see Felgueroso et al (2013) and Robles (2013) for a discussion).

The negative impact of ageing does not show in those individuals with university studies until very late (the fourth cohort). We find also here several factors that may explain such behaviour. First, the fact that lot of people in the second cohort kept studying (50 % of the

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[9] *It is worth not mistaking this process of depreciation by cohorts described by our cross-sectional data with the intrinsic depreciation of a given generation over time. Although similar patterns are both in cross-section and longitudinal data, the cohort effects may entail substantial differences (see Desjardins & Warnke (2012) for a discussion).*

[10] *This is assuming that they finish their studies in the corresponding year, which is not always the case. Indeed, many students are finishing their degrees around 25 years of age.*

people in the first cohort with university degrees were continuing their studies). Second, the job market seems to enhance this extension of the learning process in a two-fold way. On the one hand, the unemployment rate goes down with age much faster for the population with university studies. On the other hand, because the quality of employment also increases very rapidly with age for those individuals (the share of temporary occupied over the occupied is halved from one cohort to the next). So, people with university studies end later their formal education and exhibit better employment conditions, which may delay the depreciation of cognitive skills.

Yet there may also be other variables that affect negatively the younger cohorts with university studies. One is that the extension of tertiary education may involve some trade-off between quantity and quality (especially bearing in mind the small fraction of 15-year old students in the higher levels of competence shown by the PISA surveys). There is also some evidence that the adjustment between education and employment may better for the intermediate cohorts than for the younger ones (negative effects of over-qualification on the preservation of abilities). Finally, we cannot exclude the presence of differences in the quality of university studies between the intermediate cohorts and the youngest and oldest cohorts.[11]

Table 5: Unemployment and temporary employment by cohorts and educational achievements (%)

Cohorts	Unemployment rate	Long run unemployment rate	Ratio temporary employed /employed
Compulsory education			
24 or less	59.69	30.12	50.39
25-34	38.34	18.88	30.85
35-44	31.36	16.26	23.17
45-54	28.52	16.34	16.43
55 or more	21.90	14.14	8.61
Secondary education			
24 or less	45.28	16.85	55.32
25-34	24.46	10.57	26.42
35-44	20.96	9.79	17.00
45-54	16.02	8.60	10.58
55 or more	14.62	9.79	5.58
University studies			
24 or less	37.78	9.71	75.23
25-34	17.51	7.17	32.03
35-44	10.43	5.00	14.02
45-54	7.36	3.62	6.49
55 or more	6.91	4.00	3.77

Source: INE, EPA Primer Trimestre 2012

It is worth mentioning that there is no evidence of relevant changes in the composition of the studies concerning the scientific or literary orientation (see Robles (2013)).

Differences by Age: The Impact of Education

There is extensive evidence on the importance of formal education in cognitive skills (Statistics Canada & OECD (2000), (2005), Desjardins (2003), Ijzendoorn et al (2005)). Separate evaluation of the population by age allows us to estimate the relevance of non-compulsory with respect to compulsory education through the generations.

[11] One may also consider that the depreciation of knowledge in this population exhibits a greater durability. This is a subject under discussion about which the data do not yet give enough evidence (Desjardins & Warnke (2012, p. 47).

The data clearly show three relevant features in the cohort profiles. First, there is a lower relative value for university education in the youngest generation: 6.4 times the worth of compulsory education compared to between 9.2 and 13 times for the other cohorts, with a maximum for the fourth cohort (the same happens with university education relative to secondary education, as seen from the data in the footnote nº 8). Second, the worth of secondary education in the second cohort differs from the pattern of the rest of the cohorts, as it drops below that of the third. And third, the relative worth of university education with respect to compulsory education drops noticeably in the oldest generation with respect to the previous cohort (the same happens when we compare the worth of university studies relative to secondary education).

The elements that can explain those differences have already been mentioned. On the one hand, the outcomes of the population with compulsory or secondary studies aged 24 or less are not fully comparable with those of other cohorts. The reason is that such a cohort includes, among the population with compulsory or secondary education, many individuals who will end up with higher education (more than half of the youngest generation kept studying when the test was carried out). They are endowed, therefore, with abilities that go beyond the average educational achievement they have reached at the time of the survey. On the other hand, the quality of the university studies of the youngest may be less than that of older cohorts as a result of the late changes in the university system (the particular way of implementing the adaptation of the Spanish university system to the European Space of Higher Education).[12]

The generation between 25 and 35 years old is the one that has experienced the educational change associated with the LOGSE, which started to be implemented from 1991 until completion in 2002. The results of individuals in this cohort with compulsory and secondary education may be reflecting the adjustment costs of the reform. This effect is not clear for those with university studies.

Finally, the relative worth of university studies drops noticeably in the last generation, contrary to what happens with secondary education. Thus we note that the greater relevance of having university studies in that cohort does not offset the depreciation of knowledge due to ageing (even though the worth of the university studies for this last cohort would still be above that of the third). It is possible that the quality of university studies of that generation is below the previous ones and also that the share of people early retired may be significant, which would induce a sharper decline of cognitive skills.[13]

An Overall Evaluation of The Cohorts

The above results are based on the analysis of the distribution according to competence levels of the population of each cohort and formative stage. Let us consider now the educational structure of the different cohorts. That is, the distribution of educational achievement within each cohort (see Table 6).

[12] Note that the population of less than 24 years old that has achieved a university degree is very close to having finished their studies in the time theoretically required (so that there will be a significant fraction of the best university students of their generation in this cohort). Furthermore, we also find in this case that half of the young people with university studies were still studying when the tests were performed, which would also be redundant in a higher valuation.

[13] This is an aspect that requires further analysis, as it is not easy to identify what is behind the smaller worth of university studies in the older generation.

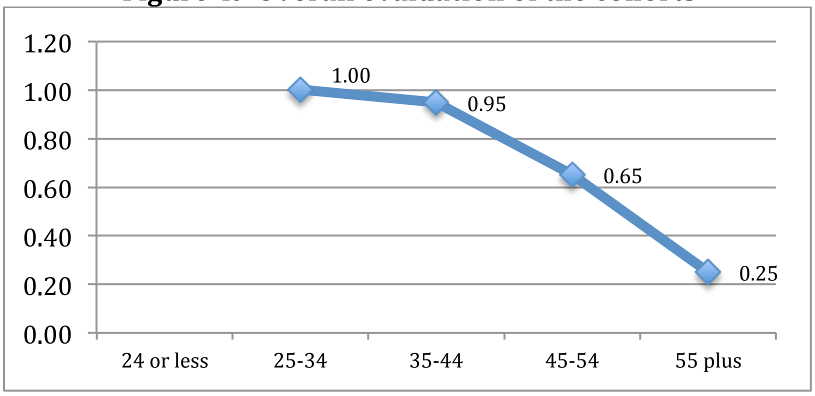
Table 6: Distribution of the educational achievements by cohorts (%)

	Studies		
Cohorts	**Compulsory**	**Intermediate**	**University**
24 or less	52.03	41.10	6.87
25-34	34.07	36.87	29.06
35-44	39.54	33.36	27.10
45-54	49.81	28.58	21.62
55 or more	63.96	22.66	13.38

The data show the extension of non-compulsory education in Spain during the last decades (66 % in the second cohort versus 36 % in the oldest one).[14] We can combine these data with those in Table 3 (A) in order to get an ***overall evaluation of the cohorts***. To do this we attach to each cohort a value that corresponds to the weighted average of the worth of the different educational achievements, using as weights the corresponding fraction of the population.

The results of this exercise are described below (Figure 4) taking the value of the second cohort equal to one and leaving the first cohort out of the comparison, for the reasons stated in footnote nº 14.

Figure 4.- Overall evaluation of the cohorts



The graphic shows a profile that clearly decreases with age. The worth of the fourth generation is around 70% of that of the third and the value of the fifth does not reach 40% of that of the fourth. The sharp drop in the valuation of the fourth and fifth cohorts is derived from the combination of the lower value of the older cohorts for each formative stage, with the smaller proportion of population with higher education in these cohorts.

CONCLUSIONS

In this study we have carried out an evaluation of the cognitive skills of the different generations, using the information on the distributions of each group in the five competence levels defined in PIAAC. The evaluation of each group is associated with the probability that a randomly chosen member of a group be in a higher level of competence than any other

[14] The distribution of educational achievements of the youngest generation deserves a separate comment in the light of the values of the population with university studies and compulsory education. The low proportion of the population with university studies is explained by the fact that only a small fraction of those individuals between 16 and 24 years old may have completed their university studies, due to age. Moreover, more than half of the individuals in this cohort are still studying (60% among those with compulsory education, 65% of those with intermediate education and 50% of those with university education). Consequently, the figures on the distribution of educational achievements in this cohort may be very misleading.

individual randomly chosen from the other groups. It is interesting to highlight that our evaluation discriminates much more between groups than the average scores of the test does.

The results obtained clearly indicate that formal education is the basic determinant of the relative value of human capital of the different cohorts. This conclusion is in line with the results of other studies, in particular the analysis of Desjardins (2003) on reading literacy in adults: education turns out to be the key variable in explaining this competence, over and above the role played by the family environment or experience in the workplace.

The depreciation of cognitive skills due to ageing is another of the relevant aspects of the results obtained, with noticeable differences both in terms of levels as well as rates of variation for the different educational achievements. This depreciation results in a reduction in proportions of population in the higher competence levels and an increase of the population at the lower levels. One of the variables that seems highly related to the depreciation of cognitive skills is the number of years elapsed since finishing formal studies until the realization of the PIAAC test. This would reflect the delay effect in depreciation due to the accumulation of so-called *crystallized cognitive skills*.

The employment status is another element that appears as playing a role in the depreciation of cognitive skills. Unemployment and job instability not only affect the income and welfare of families but they also undermine human capital, so that part of the investment in education is rapidly lost due to these circumstances.

Our evaluation also points out that the changes in educational structure may have relevant implications for the future performance of the generations that experience them. Both the introduction of the LOGSE and the particular adaptation to the European Space of Higher Education carried out in our country seem to have had some negative implications on the cognitive skills of the generations that have suffered the change.

Finally, let us mention that the outcomes of our study suggest that we should be cautious when interpreting the message that today's young people are the ever best educated generation. While Figure 4 seems to support that conclusion, it must be remembered that the higher overall worth of young people from 25 to 34 years old has much more to do with the percentage of population with higher education than with the differential value of their cognitive skills when compared to their peers. The separate evaluations by educational achievements and by age show just this.

From this analysis it follows that continued learning processes and adequate integration into the labour market are the key tools for maintaining human capital investments, due to its effect in delaying the depreciation associated with ageing. Let us recall here that the good results of the first cohort with respect to the second, for secondary and compulsory education, are partly related to the fact that many of these individuals were still studying. And also that individuals with university studies exhibit a slower pattern of decay. The current high levels of unemployment, mostly among the young (with the associated deterioration of the cognitive skills achieved), the process of progressive ageing of the population, the fast technological changes, and the delay of the retirement age, mean that finding effective ways to update and improve education is especially relevant. In the words of the OECD's General Secretary: "The most promising solution to these challenges is to invest effectively in the development of skills throughout the life cycle; from earliest childhood, through compulsory education, and throughout the whole working life "(OECD (2012, p.3)).

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