Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

https://doi.org/10.23913/ride.v16i31.2569

Artículos científicos

Socioeconomic and demographic determinants of cognitive skills in Mexico: PIAAC evidence

Determinantes socioeconómicos y demográficos de las habilidades cognitivas en México: evidencia PIAAC

Determinantes socioeconômicos e demográficos das habilidades cognitivas no México: evidências do PIAAC

Beatriz M. Terán-Pérez
Universidad Autónoma de Sinaloa, Facultad de Ciencias Económicas y Sociales, México
bea.teran@uas.edu.mx
https://orcid.org/0000-0002-7561-9938

Norma Aida Valenzuela Sánchez
Universidad Autónoma de Sinaloa, Facultad de Ciencias Económicas y Sociales, México
normavalenzuela@uas.edu.mx
https://orcid.org/0000-0003-3415-182X

Abstract

The main objective of this article is to examine the determinants of cognitive skills in the adult population of Mexico, as measured by the Program for the International Assessment of Adult Competencies (PIAAC). A multiple linear regression model is estimated, which enables the quantification of the effect of various socioeconomic and demographic variables on individuals' cognitive skills. Regarding gender, men show an advantage in numeracy skills, while women tend to excel in literacy skills. However, deteriorating health and advancing age negatively affect cognitive performance. Furthermore, education level, work experience, and participation in training courses positively and significantly influence these skills. These findings provide robust evidence on the importance of investment in formal and non-formal education and training, as well as the need for policies that promote the continuous improvement of cognitive skills throughout working life.

Keywords: competencies, education, human capital, PIAAC, skills.

Resumen

El objetivo principal de este artículo es analizar los determinantes de las habilidades cognitivas en la población adulta de México, según las habilidades evaluadas por el Programa para la Evaluación Internacional de las Competencias de los Adultos (PIAAC). Se estima un modelo de regresión lineal múltiple que permite cuantificar el efecto de diversas variables socioeconómicas y demográficas sobre las habilidades cognitivas de los individuos. Los resultados muestran que, respecto al género, los hombres presentan una ventaja en habilidades numéricas, mientras que las mujeres tienden a sobresalir en lectoescritura. Sin embargo, el deterioro de la salud y el aumento de la edad tienen un efecto negativo en las competencias. Además, el nivel de escolaridad, la experiencia laboral y la participación en cursos de capacitación ejercen un efecto positivo y significativo sobre dichas habilidades. Estos hallazgos proporcionan evidencia robusta sobre la importancia de invertir en educación y capacitación, tanto formal como no formal, así como la necesidad de políticas que promuevan la mejora continua de las competencias cognitivas a lo largo de la vida laboral.

Palabras Clave: competencias, educación, capital humano, PIAAC, habilidades.

Resumo

O principal objetivo deste artigo é analisar os determinantes das habilidades cognitivas na população adulta mexicana, com base nas habilidades avaliadas pelo Programa Internacional de Avaliação de Competências de Adultos (PIAAC). Um modelo de regressão linear múltipla é estimado para quantificar o efeito de várias variáveis socioeconômicas e demográficas nas habilidades cognitivas dos indivíduos. Os resultados mostram que, em relação ao gênero, os homens têm uma vantagem em habilidades numéricas, enquanto as mulheres tendem a se destacar em alfabetização. No entanto, o declínio da saúde e o aumento da idade têm um efeito negativo sobre essas habilidades. Além disso, o nível educacional, a experiência de trabalho e a participação em cursos de treinamento têm um efeito positivo e significativo sobre essas habilidades. Essas descobertas fornecem evidências robustas da importância de investir em educação e treinamento, tanto formal quanto não formal, bem como da necessidade de políticas que promovam a melhoria contínua das habilidades cognitivas ao longo da vida profissional.

CC BY

Palavras-chave: competências, educação, capital humano, PIAAC, habilidades.

Fecha Recepción: Febrero 2025 **Fecha Aceptación:** Junio 2025

Introduction

Human capital is defined as the stock of knowledge, competencies, or skills that an employee accumulates throughout their life. It represents an increasingly relevant element for a country's economic development and income distribution (Serrano et al., 2017; Égert et al., 2024; Sobiech et al., 2025). In this sense, developing cognitive skills, such as arithmetic and literacy, is essential for individuals to successfully integrate into a labor market that demands adaptability and constant learning.

The population's skills are vital in modern knowledge-based economies (Hanushek et al., 2015; Jimeno et al., 2016). Economic research has a large body of work on cognitive skills and the notable positive effect on departmental GDP per capita growth (Jiménez-Ramírez & Reyes-Camargo, 2024). Likewise, the development of cognitive skills is a measure of educational success and a predictor of labor market outcomes (Rebollo-Sanz & De la Rica, 2020; Mishra et al., 2025). Research, such as that of Chetty et al. (2014), has highlighted the impact of social and educational factors on the acquisition of these skills. Other authors, including Wiener et al. (2025) and Hanushek et al. (2025), have shown that cognitive skills have a direct influence on economic development.

Although consensus is lacking on which skills most influence labor market success, studies agree that cognitive skills (e.g., literacy, numeracy) are particularly relevant, those related to personal characteristics (emotional stability, empathy), and others that arise from the interaction of both components, for example, communication and self-organization (Arroyo & Valenzuela, 2018). According to Van Laar et al. (2020), demographic and socioeconomic factors, such as age, gender, and educational level, are significant determinants of technical and informational skills. In contrast, psychological factors significantly influence creativity and critical thinking.

In the case of Mexico, data from the Programme for the International Assessment of Adult Competencies (PIAAC) reveal that a significant part of the adult population has low levels of cognitive skills compared to other countries in the Organisation for Economic Cooperation and Development (OECD), with averages of around level 1.7 in reading and 1.5 in mathematics, on a scale where the maximum level is five (Valenzuela & Palomares, 2023). This scenario presents significant challenges for developing human capital and,

CC BY

consequently, for the country's growth and competitiveness in the global market. Mexico's problem lies in significant disparities in the development of cognitive skills, associated with structural factors such as inequality in access to education and individual and family conditions.

This study examines the sociodemographic, educational, and occupational factors influencing cognitive skills in the Mexican adult population, utilizing data from the Program for the International Assessment of Adult Competencies (PIAAC). A multiple linear regression model is used to quantify the effect of variables such as educational level, age, gender, parental education, work experience, participation in training courses, and health status on *literacy* and *numeracy* skills.

The main contribution of this work lies in providing recent and specific empirical evidence for the case of Mexico. This country has been underexplored in this type of analysis based on microdata from the PIAAC. Unlike studies focused on developed country contexts or those that employ aggregate approaches, this analysis adopts an individual perspective, enabling the identification of inequalities in human capital development. Furthermore, the methodological use of plausible scores and the proposed statistical approach reinforces the robustness of the analysis and makes it replicable for future studies.

In this way, the study not only deepens our understanding of the factors that influence the development of cognitive skills but also offers valuable analytical tools for designing public policies aimed at strengthening lifelong learning, improving employability, and reducing structural gaps among vulnerable groups in the Mexican adult population.

Human capital and cognitive skills

The concept of human capital, developed by Gary Becker in 1964, refers to the knowledge, skills, competencies, and attributes that individuals acquire through education, training, and experience, thereby increasing their productivity in the labor market (Becker, 1993). Its most relevant components include formal education, professional experience, health, and, notably, cognitive skills, which are understood as the ability to comprehend, process, and utilize information effectively. These skills, including literacy, mathematical reasoning, and problem-solving, are essential for lifelong learning, effective job performance, and civic participation (OECD, 2012). According to Hanushek et al. (2015, 2025), cognitive skills encompass the ability to comprehend complex ideas, adapt effectively to the environment,

learn from experience, employ diverse forms of reasoning, and overcome obstacles through thoughtful analysis.

Various studies on human capital accumulation have traditionally used indicators such as years of schooling or educational level to represent knowledge. Although these indirect indicators are common in empirical research, they have significant limitations: they do not adequately capture the quality of education nor allow for establishing a precise relationship between schooling and effective skills, especially when analyzing the competencies of the adult population (Calero et al., 2019).

The knowledge acquired can vary significantly depending on how effectively schooling is transformed into skills. Furthermore, using (or disusing) these skills in the workplace overtime also determines how effectively formal education reflects individuals' actual competencies (Hanushek et al., 2015).

One of the first studies introducing cognitive skills as a direct measure of human capital was that of Hanushek & Kimko (2000). Using the results of international tests administered by the International Association for the Evaluation of Educational Achievement (IEA) and the International Assessment of Educational Progress (IAEP) in 31 countries between 1960 and 1990, the authors found a strong positive relationship between cognitive skills and economic growth.

Since then, several studies have delved deeper into the empirical measurement of skills, demonstrating that not only formal education but also the skills acquired have a significant impact on income, inequality, and economic growth (Agasisti et al., 2020; Bechichi et al., 2018). This research has opened up new avenues for exploring the factors that determine how skills are acquired and maintained in adulthood.

According to Villar (2013), the dynamics of cognitive skills are complex and respond to both individual and social factors. At the individual level, these factors are influenced by neuronal maturation processes, the accumulation of knowledge and experience, and continuous interaction with a changing environment. At the societal level, structural changes, such as the expansion of compulsory education or generational shifts, affect cohorts differently, modifying skill acquisition and retention patterns.

In this regard, Anghel & Lacuesta (2020) point out that physical, numeracy, literacy, and digital skills tend to deteriorate with age, which can limit productivity in specific sectors. However, factors such as company size, labor flexibility, retirement plans tailored to the

CC BY

required skills, and a robust continuing education offering can mitigate this loss and increase the employability of older workers.

Another crucial element in skills development is gender. Battisti et al. (2023) identify that while progress has been made in educational equity, considerable gaps persist in numeracy skills, favoring men. Women face greater disadvantages, especially in the upper segments of the wage distribution. These gaps reflect not only inequalities in training but also the lower returns to skills for women.

Likewise, Acosta et al. (2020) found, in a study of the adult population in Colombia, that individuals with higher levels of cognitive and socioemotional skills secure better jobs—more formal, higher-paying, and less manual labor-intensive—and are more likely to have completed higher education. While socioemotional skills have a positive effect, their impact is less than that of cognitive skills.

Most empirical estimates have been based on cross-sectional surveys such as the International Adult Literacy Survey (IALS), the Adult Literacy and Life Skills Survey (ALL), and the Longitudinal Study of Adult Learning (LSAL), which suggest that skills begin to decline after age 30 (Abrassart, 2013; Flisi et al., 2017). However, more recent studies combining these sources with data from the PIAAC have found that the decline can begin as early as age 16, depending on the educational level achieved and the type of skills assessed (Calero et al., 2019; Barth et al., 2021; Shields & Sandoval Hernández, 2020).

Finally, several studies have shown that the development of cognitive skills is closely linked to socioeconomic, educational, and gender factors. In Latin America, Bonavida & Gasparini (2024) utilize data from the PIAAC to demonstrate how gaps in numerical skills identified at school age persist into adulthood, influencing the types of tasks performed by men and women and contributing to part of the wage gap. Internationally, Aesaert & van Braak (2015) demonstrate that differences in gender and socioeconomic status also significantly impact digital skills, particularly when measured through achievement tests rather than self-assessments.

CC BY

Mexican context and skills gaps

In the Mexican context, Vázquez & Mireles-Cárdenas (2024) highlight the importance of critical thinking and information literacy skills in upper secondary education as key tools for university and career readiness. In turn, Heffington et al. (2023) emphasize that although the development of higher-order thinking skills is included in the basic education curriculum, its implementation faces methodological and conceptual obstacles. These challenges limit the education system's capacity to foster transferable skills. Overall, the literature agrees that the quality and type of education received at early stages are determinants of human capital, which can be effectively measured using instruments such as the PIAAC (OECD, 2020; Bonavida & Gasparini, 2024). This reaffirms the need for more targeted and inclusive education and labor market policies.

Despite the wealth of previous studies, much of the existing literature has focused on international contexts or early educational stages, leaving the analysis of the factors that determine cognitive abilities in the Mexican adult population with relatively recent empirical evidence. In this sense, one of this work's main contributions is the use of microdata from the PIAAC Mexico to estimate the effect of socioeconomic and demographic variables on adult literacy and numeracy skills. Unlike previous research focused on the school setting (Vázquez & Mireles-Cárdenas, 2024; Heffington et al., 2023) or samples from other countries (Battisti et al., 2023; Acosta et al., 2020), this study allows us to identify persistent inequalities in cognitive abilities based on educational level attained, health, age, work experience, gender, and parental education, providing contextualized evidence for the design of public policies in Mexico. In addition, it offers an intergenerational and life-cycle perspective that allows us to understand how skills are acquired and how they are maintained, deteriorated, or enhanced over time.

It is hypothesized that the cognitive abilities of adults in Mexico are significantly determined by sociodemographic, educational, and occupational factors, such that higher levels of education, employment, and participation in learning activities are associated with better performance in literacy and numeracy.

This study aims to estimate the effects of socioeconomic, demographic, and occupational factors on the cognitive skills of Mexican adults, using PIAAC data.

PIAAC: Instrument and applications

The Programme for the International Assessment of Adult Competencies (PIAAC), promoted by the Organisation for Economic Co-operation and Development (OECD), is one of the most comprehensive international initiatives to directly measure the key skills adults apply in their everyday, educational, and work environments. Through a rigorous and standardized methodology, PIAAC assesses three fundamental domains: literacy, numeracy, and problem-solving in technology-rich environments, allowing for comparisons across countries and population segments (OECD, 2012; OECD, 2013).

The PIAAC methodological design is based on a multistage, stratified probability sampling scheme, ensuring national representativeness. The survey consists of two parts: a background questionnaire and a competency assessment administered in a booklet or on a computer. This assessment focuses on three domains: literacy, numeracy, and problem-solving in technology-rich environments. The assessment items are constructed from tasks based on real-life situations and calibrated using Item Response Theory (IRT). Each participant receives a continuous score on a scale of 0 to 500 points, based on the average of ten plausible values that capture their expected performance, minimizing measurement error (OECD, 2019).

Literacy competency refers to the ability to understand, use, evaluate, and reflect on written texts to achieve personal goals, develop professionally, and actively participate in society. *Numeracy*, on the other hand, involves interpreting and applying mathematical concepts in real-life contexts, which is essential for making informed decisions. *Problem-solving* skills focus on using digital technology to solve practical problems, which requires locating information, critically evaluating it, and executing actions within computerized environments (OECD, 2013).

In its application in Mexico, the PIAAC provides representative information on the adult population between 16 and 65 years of age, assessing not only the level of proficiency but also the frequency with which these skills are used in the workplace. According to the most recent results, a significant portion of the Mexican population is at the lowest performance levels, particularly in *numeracy* and *problem-solving*, which poses significant challenges to productive inclusion and educational equity in the country (OECD, 2020). The OECD Skills Diagnostic Report for Mexico (OECD, 2017) highlights the urgent need to strengthen core competencies throughout the workforce, noting that low utilization of skills at work limits productivity and the country's capacity for technological adaptation.

CC BY

The PIAAC survey is designed to be cross-culturally and internationally valid, to be administered in the languages of the participating countries, obtaining comparable results that can be applied in other years and allowing for comparison of the development of critical aspects of human capital (Engelhardt et al., 2021; Yildirim & Cui, 2022). The survey results are based on collaboration between the participating countries, the Organisation for Economic Cooperation and Development (OECD) secretariat, and the international consortium led by the Educational Testing Service (ETS). According to Table 1, in the first cycle of the PIAAC, 39 countries/economies participated in the survey between 2011 and 2018. The data were collected in three different rounds; the first directly assessed the skills of approximately 150,000 working-age adults (16–65 years) surveyed in 24 countries of the European Community and America (only Canada and the USA). Three Latin American countries (Chile, Ecuador, and Mexico) have been considered for the second and third rounds.

Table 1. Participating countries in PIAAC

Round 1 (2011-2012)	Australia, Austria, Belgium, Canada, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Japan, Korea, Netherlands, Norway, Poland, Russian Federation, Slovak Republic, Spain, Sweden, United Kingdom, United States
Round 2 (2014-2015)	Chile, Greece, Indonesia, Israel, Lithuania, New Zealand, Singapore, Slovenia, Türkiye
Round 3 (2016-2017)	Ecuador, Hungary, Kazakhstan, **Mexico,** Peru, United States

Source: Adapted from the OECD (2024)

The literature review allows to identify several studies that use PIAAC data with multiple statistical techniques; for example, Huertas and Raymond (2024) use a multinomial logit model to predict the effect of higher schooling on the probability of accessing a highly skilled job and analyze whether the magnitude of this effect depends on the (mis)match between the education attained by workers and the education required by jobs. Maehler et al. (2024) use longitudinal data from the skills assessment available in PIAAC to offer insights into the mechanisms underlying changes and stability of cognitive skills in different age cohorts; the study is an essential contribution to the existing literature and provides empirical evidence derived from a robust (representative) dataset and internationally comparable measurements. Pensiero & Barone (2024) analyze the extent to which respondents' education and cognitive skills mediate the overall association between parents' education and respondents' income in the two surveys. They use the product method to quantify the indirect effects between variables.

Methodology

The contemporary labor market requires technical skills and a solid cognitive foundation that enables individuals to adapt to a constantly changing work environment (Sevilla & Farias, 2020; Huertas & Raymond, 2024). In this sense, the methodology employed in this study aims to analyze the factors that determine individuals' cognitive skills, specifically in arithmetic and literacy skills. To achieve this, a multiple linear regression model has been implemented, which enables the quantification of the effect of various socioeconomic and demographic variables on individuals' cognitive skills, following an approach similar to that of previous studies, such as those by Hanushek & Woessmann (2008) and Chetty et al. (2014).

Data from the Program for the International Assessment of Adult Competencies (PIAAC) in Mexico are used. The sample consists of 5890 individuals aged 15 to 65 with complete information on the critical variables included in the analysis.

Description of variables

1. Cognitive skills (dependent variable): Measured through literacy and numeracy scores from the PIAAC in Mexico. Scores are reported on a continuous scale from 0 to 500, calibrated using Item Response Theory (IRT). To reduce measurement error, the OECD provides plausible values that capture functional competence. In this study, the average of the plausible values per domain is used as the measure of skill level (OECD, 2013; OECD, 2019).
2. Educational attainment: This variable captures the highest level of formal education completed by individuals. Education provides the foundation for acquiring cognitive and non-cognitive skills, which are essential for labor market performance. Prior studies show that both the quality and quantity of schooling directly influence skill development and economic outcomes (Hanushek & Woessmann, 2008; Heckman et al., 2006).
3. Age: This variable, measured in cohorts, captures life-cycle differences in cognitive abilities. Evidence shows that some skills, such as working memory, decline with age, while others, like problem-solving, may improve through accumulated experience. Adult cognitive performance also depends on early education and continued exposure to stimulating environments (Schaie, 2005; Deary et al., 2009).

CC BY

4. Gender: Gender differences can influence educational and employment outcomes, reflecting societal structural inequalities. Aesaert and van Braak (2015) demonstrated that gender influences technological and digital skills, with girls excelling in digital communication tasks and boys excelling in technical skills related to information retrieval. Battisti et al. (2023) demonstrate that these gaps account for part of the wage inequality.
5. Parental education: This variable reflects the intergenerational transmission of human capital. Higher parental schooling is strongly associated with better academic and cognitive outcomes in adulthood (Carneiro et al., 2013).
6. Work experience: This variable measures the accumulation of practical knowledge and skills through labor market participation. Empirical evidence shows that work experience complements formal education, enhances technical and soft skills, and contributes to ongoing cognitive development (Autor, 2014; Chetty et al., 2014).
7. Training courses: The variable captures participation in non-formal training, which complements formal education and helps workers adapt to technological and market changes. Such training supports the acquisition of practical skills and ensures that competencies remain relevant in dynamic labor environments (Acemoglu & Pischke, 1999).
8. Health: This variable is included based on evidence showing that poor health negatively affects cognitive performance and productivity, as documented in studies such as Pischke (2007) and Autor et al. (2003).

Econometric model

A multiple linear regression model examines how socioeconomic and demographic factors (such as educational level, work experience, and training) influence workers' cognitive abilities.

$$Skills_i = \beta_0 + \beta_1\, School\ level_i + \beta_2\, age_1 + \beta_3\, gender_i + \beta_4\, parental\ education_i + \beta_5 experience_i + \beta_6\, training_i + \beta_7 health + \varepsilon_i$$

As:

- *Skills*: Represents the individual's score in cognitive skills, either in arithmetic or reading and writing (measured on a scale of 0 to 500 points).

- *Educational attainment*: The value takes the form of one if the individual has a basic education or less, two if they have high school studies, and three if they have higher education or more.
- *Age cohorts*: Age is categorized into five age cohorts 15-24, 25-34, 35-44, 45-54, and 55-65 years.
- *Gender*: Binary variable where one is male and 0 is female.
- *Parental education*: is categorized according to whether they have completed high school or university studies.
- *Experience*: Years of work experience.
- *Training*: assigns a value of 1 if the person attends a non-formal training course.
- *Health*: Self-reported health status, categorized into three levels: good health, regular health, and poor health.

The model enables us to determine the magnitude and direction of each independent variable's impact on cognitive skills. The level of education, work experience, and participation in training courses are expected to have a positive and significant effect on numeracy and literacy skills. Likewise, deteriorating health and increasing age are expected to have a negative effect on these skills.

Various diagnostic tests were performed to ensure the validity of the regression models. The Variance Inflation Factor (VIF) test indicated no severe multicollinearity (values < 4). Residuals were normally distributed according to the Jarque-Bera test, and heteroskedasticity was not detected based on the Breusch-Pagan/Cook-Weisberg test—standardized residuals plotted against fitted values confirmed linearity and the absence of systematic patterns.

All estimates were weighted using sample expansion factors, and the plausible skill values recommended by the OECD for the appropriate use of cognitive scores (OECD, 2013) were incorporated. Statistical analysis was performed using Stata 17 software.

CC BY

Results

Data analysis

The descriptive analysis of the sample, which includes 5,890 individuals with complete information on all variables, shows that the average numeracy score is 206 points and the average literacy score is 217 points, both below 50% of the maximum possible score of 500 points. On average, participants completed 9.4 years of schooling, corresponding roughly to secondary education. The mean age of the sample is 38.8 years, and the average work experience is 11.6 years. Regarding family background, only 10% of respondents reported that at least one of their parents had completed higher education. Participation in non-formal training courses during the 12 months prior to the survey was reported by 26% of the individuals.

Table 2. *Descriptive statistics*

Variable	Average	Standard deviation	Min	Max
Numeracy skills	206.0	48.5	63.8	374.5
Literacy skills	217.4	45.7	65.2	368.6
Years of Schooling	9.4	4.9	0	23
Age	38.8	13.4	16	65
Experience work	11.6	12.4	0	55
Gender (male)	0.45	0.5	0	1
At least one of the parents has a high school education	0.18	0.4	0	1
At least one of the parents has a university education	0.09	0.3	0	1
Training courses	0.26	0.4	0	1

Source: Adapted from PIAAC data (2017), n=5890

Sample distribution by educational level and age

In terms of educational attainment, secondary education was the most frequently reached level, comprising approximately one-third of the sample (33.34%), followed by primary education (29.61%) and high school (24.06%). Fewer individuals reported completing a bachelor's degree (11.49%), a master's degree (1.12%), or a PhD (0.37%). Regarding age distribution, the majority of respondents were between 25 and 44 years old, representing nearly half of the sample. Younger adults aged 15–24 accounted for 18.40% of participants, while older adults aged 55–65 represented 16.54%.

Table 3. Distribution of the sample by educational level and age group

Variable	%
Educational attainment	
Elementary or less	29.61
Secondary	33.34
High school	24.06
Bachelor	11.49
Master	1.12
PhD	0.37
Age cohorts	
15-24	18.40
25-34	23.53
35-44	23.34
45-54	18.18
55-65	16.54

Source: Adapted from PIAAC data (2017)

Cognitive skills by age group

The analysis of cognitive skills reveals a clear trend related to age. Individuals aged 15–23 obtained the highest scores, averaging 215.08 points in numeracy and 229.77 points in literacy. Scores remain relatively stable for those aged 24–33, with minor variations. Starting from age 34, a gradual decline in cognitive skills is observed. Participants aged 34–43 scored 211.35 in numeracy and 221.28 in literacy. Those aged 44–53 experienced a more pronounced decline, with averages of 200.41 and 210.36 in numeracy and literacy,

respectively. The oldest cohort, aged 54–65, recorded the lowest scores, averaging 184.39 in numeracy and 194.75 in literacy, highlighting an age-related decrease in cognitive performance.

Table 4. Numeracy and literacy skill scores by age group

Age group	Numeracy skill	Literacy skill
15-23	215.08	229.77
24-33	215.75	228.15
34-43	211.35	221.28
44-53	200.41	210.36
54-65	184.39	194.75
Source: Adapted from PIAAC data (2017)		

Determinants of cognitive skills

Regression analysis was conducted to identify the factors influencing numeracy and literacy skills. Educational attainment emerged as the strongest predictor. Individuals who completed high school scored, on average, 24.20 points higher in literacy and 30.23 points higher in numeracy compared to those with only primary education or less. Completion of university or higher education further increased scores by 37.55 points in literacy and 44.12 points in numeracy, confirming the crucial role of advanced education in cognitive development.

Age was negatively associated with cognitive skills. Compared to the 15–24 age group, individuals aged 34–43 showed decreases of 8.75 points in literacy and 5.64 points in numeracy. Participants aged 44–53 experienced larger reductions, with 19.69 points lower in literacy and 16.21 points lower in numeracy. The oldest group, aged 54–65, exhibited the steepest declines, with reductions of 32.81 points in literacy and 30.29 points in numeracy.

Parental education also had a significant effect. Individuals whose parents completed high school gained approximately 13–15 points in both skills, while children of university-educated parents experienced increases of about 14 points, illustrating the intergenerational transmission of educational advantage.

Gender differences were observed, with men scoring lower in literacy by 2.06 points but higher in numeracy by 6.17 points, suggesting domain-specific strengths.

CC BY

Participation in non-formal training courses positively impacted on cognitive skills, yielding gains of 3.99 points in literacy and 3.67 points in numeracy. Similarly, each additional year of work experience was associated with increases of 0.32 points in literacy and 0.50 points in numeracy, emphasizing the value of continued practice and engagement in the labor market.

Health status was strongly associated with cognitive performance. Individuals reporting poor health experienced declines of 14.47 points in literacy and 13.18 points in numeracy, while those reporting fair health showed smaller reductions of around 2 points in both areas. Marital status had a minor impact, with married individuals showing a slight reduction of 1.98 points in literacy and no significant change in numeracy.

Summary of key findings

Overall, education was the most influential factor in determining cognitive skills, followed by age and parental education. Gender, participation in training courses, work experience, and health status also significantly influenced outcomes. The results highlight that cognitive skills decline with age but can be positively affected by higher educational attainment, continuous learning, and professional experience, emphasizing the importance of lifelong learning and healthy living conditions.

CC BY

Table 5. Determinants of numeracy and literacy skill levels

Variable		Literacy skill	Numeracy skill
High School		24.20 ***	30.23 ***
		(12.42)	(14.63)
Higher education		37.55 ***	44.12 ***
		(10.18)	(11.55)
Age	24-33	-3.515 *	-1.104
		(-1.95)	(-0.58)
	34-43	-8.748 ***	-5.641 **
		(-3.71)	(-2.24)
	44-53	-19.69 ***	-16.21 ***
		(-6.19)	(-4.80)
	54-65	-32.81 ***	-30.29 ***
		(-8.43)	(-7.42)
Parents with High School		13.81 ***	15.32 ***
		(8.18)	(8.46)
Parents with University		14.07 ***	13.51 ***
		(7.15)	(6.50)
Man		-2.056 *	6.167 ***
		(-1.73)	(4.87)
Training courses		3.993 ***	3.665 ***
		(3.13)	(2.75)
Experience work		0.319 ***	0.498 ***
		(4.91)	(7.25)
Regular Health		-2.127 *	-2.423 *
		(-1.70)	(-1.85)
Poor Health		-14.47 ***	-13.18 ***
		(-3.60)	(-3.10)
married		-1.981 *	-0.232
		(-1.67)	(-0.18)
constant		213.9 ***	190.9 ***
		(121.25)	(100.78)
N		5,890	5,890
R^2 adjusted		0.268	0.291

Source: Adapted from PIAAC data (2017). t statistics in brackets, * p<0.10, ** p<0.05, *** p<0.01

Discussion

The results of this study reinforce previous empirical evidence regarding the determinants of cognitive skills while highlighting specific factors that are particularly relevant for understanding these dynamics in emerging economies such as Mexico.

The strong relationship between educational attainment and performance in numeracy and literacy aligns with the findings of Hanushek & Woessmann (2008) and Heckman et al. (2006), who emphasize that both the quantity and quality of formal education are crucial for the accumulation of human capital. Nevertheless, our findings indicate that even individuals with higher education rarely reach proficiency levels near the maximum on the PIAAC scale. This gap raises questions about the effectiveness of the Mexican education system in translating years of schooling into functional and transferable skills, a concern also noted by Calero et al. (2019). Such a discrepancy may reflect both structural deficiencies in educational quality and a lack of alignment between curricular content and the skills demanded by the socioeconomic environment.

With respect to age, the observed pattern of cognitive decline is consistent with prior research, including Hanushek et al. (2025), Anghel & Lacuesta (2020), and Schaie (2005), which documents progressive skill deterioration during middle and older adulthood. However, our analysis suggests that the decline in Mexico is more pronounced than in other OECD countries. This could be related to reduced sustained exposure to cognitively demanding tasks in both work and social contexts, as well as the limited coverage and targeting of continuing education programs. Although non-formal training exhibits a positive effect on cognitive skills, the marginal impact is relatively modest, indicating that available opportunities are insufficient to reverse skill losses and are not strategically directed toward the most disadvantaged groups.

The intergenerational transmission of education, as evidenced in our results, supports the conclusions of Carneiro et al. (2013), showing that parental education exerts a positive influence on the cognitive abilities of adult children. This finding underscores the persistent reproduction of human capital inequalities across generations when early educational gaps remain unaddressed.

Another key finding deserving critical attention is the persistent gender gap in cognitive skills. Consistent with Battisti et al. (2023), men tend to outperform women in numeracy, while women excel in literacy. Importantly, these differences persist even after controlling education and other socioeconomic variables, suggesting that gender gaps reflect

deep-seated inequalities in access, socialization patterns, task allocation, and institutional expectations. As Rebollo-Sanz & De la Rica (2020) argue, such disparities in skills can contribute to wage inequalities in the labor market and should not be interpreted as natural or solely individual differences.

Our analysis also confirms the positive influence of work experience on cognitive skill development, in line with Autor (2014) and Chetty et al. (2014). However, the effect is relatively modest, potentially reflecting the segmentation of the Mexican labor market, where many workers engage in routine tasks requiring limited cognitive engagement. These findings suggest that the quality of work environments and the cognitive demands of specific occupations are more relevant than the mere duration of experience, highlighting the need for policies that enhance cognitive stimulation across an individual's working life, as also emphasized by Xu (2024).

Finally, the negative effect of poor health on cognitive performance corroborates the findings of Autor et al. (2003), who demonstrate that health status directly impacts both cognitive functioning and productivity. Often overlooked in studies of human capital, this dimension is crucial for designing comprehensive interventions that integrate educational development with physical and mental well-being.

In summary, our findings emphasize the multifaceted nature of cognitive skill development, shaped not only by formal education and age but also by parental background, gender, work experience, and health. These insights provide a foundation for targeted policies in emerging economic contexts, highlighting the need for integrated approaches that combine educational quality, lifelong learning opportunities, equitable access, and health interventions.

Conclusion

This research develops an analytical framework for understanding the role of education and human capital in shaping individuals' cognitive skills. The study identifies key variables that significantly influence these skills, which in turn have important implications for income distribution and economic growth.

The primary objective was to examine the impact of various socioeconomic and demographic factors on cognitive abilities in Mexico, using data from the Program for the International Assessment of Adult Competencies (PIAAC). The findings provide robust statistical evidence, confirming that educational attainment, parental education, work

CC BY

experience, participation in training programs, and health status play a central role in the development and maintenance of cognitive skills. Age and gender also contribute to individual variation, highlighting the multidimensional nature of skill acquisition.

These results underscore the practical importance of investing in both formal and non-formal education and training, as well as the need for policies that support lifelong learning and continuous improvement of cognitive skills across working life. While the findings align with international evidence, their analysis within the Mexican context reveals the specific challenges of a highly unequal education and labor system.

Public policies aiming to strengthen human capital must go beyond expanding educational coverage. They should focus on enhancing the quality of learning, aligning educational outcomes with labor market demands, and providing targeted continuing education programs for the most disadvantaged populations. Moreover, it is essential to adopt an intersectional perspective that addresses overlapping inequalities related to age, gender, social class, and health, ensuring that interventions are equitable and effective.

In conclusion, this study highlights the complex interplay of individual, familial, and contextual factors in shaping cognitive skills, offering evidence-based guidance for designing inclusive policies that foster human capital development and promote social and economic equity in Mexico.

Future lines of research

Although this study provides valuable insights into the determinants of cognitive skills, it has certain limitations that open avenues for future research. First, while key variables affecting the development of reading, writing, and numeracy skills have been identified, other factors—such as socio-emotional competencies, family environment, and labor market participation—may also play a significant role. Future studies could aim to enhance and refine the regression models presented here by incorporating these additional determinants to achieve a more comprehensive understanding of skill development.

Second, this research focuses exclusively on the adult population in Mexico and does not explore cross-country differences in cognitive skills. Expanding the scope to include comparisons across Latin American countries surveyed by PIAAC or analyzing cognitive abilities across the three PIAAC rounds internationally would allow researchers to identify regional patterns, similarities, and divergences. Such comparative studies could provide

CC BY

critical insights for designing policies that promote human capital development in diverse socioeconomic and cultural contexts.

References

Abrassart, A. (2013). Cognitive skills matter: The employment disadvantage of low educated workers in comparative perspective. *European Sociological Review*, 29(4), 707-719. https://doi.org/10.1093/esr/jcs049.

Acemoglu, D. & Pischke, J. S. (1999). The structure of wages and investment in general training. *Journal of Political Economy*, 107(3), 539-572. https://doi.org/10.1086/250071

Acosta, P., Muller, N., & Sarzosa, M. (2020). Adults' Cognitive and Socioemotional Skills and Their Labor Market Outcomes in Colombia. *Revista De Economía Del Rosario*, 23(1), 109-148. https://doi.org/10.12804/revistas.urosario.edu.co/economia/a.8628.

Aesaert, K., & van Braak, J. (2015). Gender and socioeconomic related differences in performance-based ICT competences. *Computers & Education*, 84, 8-25. https://doi.org/10.1016/j.compedu.2014.12.017

Agasisti, T., Johnes, G. & Paccagnella, M. (2020). Tasks, occupations and wages in OECD countries. *International Labour Review*, 160(1), 85-112. https://doi.org/10.1111/ilr.12169.

Anghel, B., y Lacuesta, A. (2020). Envejecimiento y evolución del capital humano a lo largo de la vida laboral. *Papeles de Economía Española*, (166), 144-165.

Arroyo, C., y Valenzuela, A. (2018). PIAAC: Competencias de la población adulta en Chile, un análisis al sistema educativo y mercado laboral. *Comisión Nacional de productividad*.

Autor, D. H. (2014). Skills, education, and the rise of earnings inequality among the "other 99 percent". *Science*, 344(6186), 843-851. https://doi.org/10.1126/science.1251868

Autor, D. H., Levy, F., & Murnane, R. J. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *Quarterly Journal of Economics*, 118(4), 1279-1333. https://doi.org/10.1162/003355303322552801

Bechichi, N., Grundke, R., Jamet, S., & Squicciarini, M. (2018). Moving between jobs. *OECD Science, Technology and Industry Policy Papers*, No. 52. Paris: OECD Publishing. https://doi.org/10.1787/d35017ee-en.

Becker, G. S. (1993). Human capital: A theoretical and empirical analysis with special reference to education (3ª ed.). *National Bureau of Economic Research.*

Barth, E., Keute, A. L., Schøne, P., von Simson, K., & Steffensen, K. (2021). NEET status and early versus later skills among young adults: Evidence from linked register-PIAAC data. *Scandinavian Journal of Educational Research*, 65(1), 140-152. https://doi.org/10.1080/00313831.2019.1659403

Battisti, M., Fedorets, A., & Kinne, L. (2023) Cognitive Skills Among Adults: An Impeding Factor for Gender Convergence? CESifo Working Paper No. 10428, http://dx.doi.org/10.2139/ssrn.4456360

Bonavida, C., y Gasparini, L. (2024). El rol de las habilidades y las tareas en las brechas de género en América Latina (Documento de Trabajo No. 330). CEDLAS, Universidad Nacional de la Plata. https://www.cedlas.econo.unlp.edu.ar/wp/wp-content/uploads/doc_cedlas330.pdf?dl=0

Calero, J., Murillo Huertas, I. P., & Raymond Bara, J. L. (2019). Education, age and skills: An analysis using PIAAC data. *European Journal of Education*, 54(1), 72-92. https://doi.org/10.1111/ejed.12318.

Carneiro, P., Meghir, C., & Parey, M. (2013). Maternal education, home environments, and the development of children and adolescents. *Journal of the European Economic Association*, 11(s1), 123-160. https://doi.org/10.1111/j.1542-4774.2012.01096.x

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014). Measuring the impacts of teachers II: Teacher value-added and student outcomes in adulthood. *American Economic Review*, 104(9), 2633-2679. DOI: 10.1257/aer.104.9.2633

Deary, I. J., Whiteman, M. C., Starr, J. M., Whalley, L. J., & Fox, H. C. (2009). The impact of childhood intelligence on later life: Following up the Scottish mental surveys of 1932 and 1947. *Journal of Personality and Social Psychology*, 86(1), 130-147. https://doi.org/10.1037/0022-3514.86.1.130

Engelhardt, L., Goldhammer, F., Lüdtke, O., Köller, O., Baumert, J., & Carstensen, C. H. (2021). Separating PIAAC competencies from general cognitive skills: A dimensionality and explanatory analysis. *Studies in Educational Evaluation*, 71, 101069. https://doi.org/10.1016/j.stueduc.2021.101069.

Égert, B., De la Maisonneuve, C., & Turner, D. (2024). A new macroeconomic measure of human capital exploiting PISA and PIAAC: Linking education policies to

productivity. *Education Economics*, 1-17. https://doi.org/10.1080/09645292.2024.2318221.

Flisi, S., Goglio, V., Meroni, E. C., Rodrigues, M., & Vera-Toscano, E. (2017). Measuring occupational mismatch: Overeducation and overskill in Europe—Evidence from PIAAC. *Social Indicators Research*, 131(3), 1211-1249. https://link.springer.com/article/10.1007/s11205-016-1292-7.

Hanushek, E. A., & Kimko, D. D. (2000). Schooling, labor-force quality, and the growth of nations. *American Economic Review*, 90(5), 1184-1208. https://doi.org/10.1257/aer.90.5.1184.

Hanushek, E. A., Kinne, L., Witthöft, F., & Woessmann, L. (2025). Age and cognitive skills: Use it or lose it. Science Advances, 11(10), eads1560. https://doi.org/10.1126/sciadv.ads1560

Hanushek, E. A., Schwerdt, G., Wiederhold, S., & Woessmann, L. (2015). Returns to skills around the world: Evidence from PIAAC. *European Economic Review*, 73, 103-130. https://doi.org/10.1016/j.euroecorev.2014.10.006.

Hanushek, E. A., & Woessmann, L. (2008). The role of cognitive skills in economic development. *Journal of Economic Literature*, 46(3), 607-668. https://doi.org/10.1257/jel.46.3.607

Heckman, J. J., Stixrud, J., & Urzua, S. (2006). The effects of cognitive and noncognitive abilities on labor market outcomes and social behavior. *Journal of Labor Economics*, 24(3), 411-482. https://doi.org/10.1086/504455

Heffington, D. V., Cabañas Victoria, V. V., Dzay Chulim, F. y Negrete Cetina, M. (2023). La enseñanza de habilidades de pensamiento superior en escuelas primarias públicas en México. *Revista Educación*, 47(1). https://doi.org/10.15517/revedu.v47i1.51740

Huertas, I.P.M., & Raymond, J.L. (2024). Education, educational mismatch and occupational status: an analysis using PIAAC data. *Economía Política*. https://doi.org/10.1007/s40888-024-00328-z

Jimeno, J. F., Lacuesta, A., Martínez-Matute, M., & E., V. (2016). Education, labour market experience and cognitive skills. OECD Education Working Paper No. 146. Paris: OECD Publishing. https://doi.org/10.1787/5jlphd2qj19n-en.

Jiménez-Ramírez, S. y Reyes-Camargo, S. (2024). Habilidades cognitivas, calidad de la educación y crecimiento económico en los departamentos de Colombia: un marco de

variables instrumentales. *Equidad y Desarrollo*, (43). https://doi.org/10.19052/eq.vol1.iss43.4

Maehler, D. B., Martin, S., Gorges, J., & Scherer, R. (2024). Determinants of cognitive skills in adulthood: Age cohort patterns. *International Journal of Lifelong Education*, 1-22. https://doi.org/10.1080/02601370.2024.2390070

OECD. (2012). Literacy, Numeracy and Problem Solving in Technology-Rich Environments: Framework for the OECD Survey of Adult Skills. OECD Publishing. https://doi.org/10.1787/9789264128859-en

OECD. (2013). The Survey of Adult Skills: Reader's Companion. OECD Publishing. https://doi.org/10.1787/9789264204027-en

OECD. (2020). *Country Note - México PIAAC*. https://www.oecd.org/centrodemexico/medios/Country%20note%20-%20%20Mexico_espa%C3%B1ol.pdf

OECD. (2017). OECD Skills Strategy Diagnostic Report: Mexico 2017. OECD Skills Studies. OECD Publishing. https://doi.org/10.1787/9789264287679-en

Mishra, C. E., Walters, D., Fraser, E. D., Gillis, D., & Jacobs, S. (2025). Higher Education Fields of Study and the Use of Transferable Skills at Work: An Analysis Using Data from the Programme for the International Assessment of Adult Competencies (PIAAC) in Canada. *Trends in Higher Education*, 4(2), 19. https://doi.org/10.3390/higheredu4020019

Pensiero, N., & Barone, C. (2024). Parental schooling, educational attainment, skills, and earnings: A trend analysis across fifteen countries. *Social Forces*, 102(4), 1288-1309. https://doi.org/10.1093/sf/soad144

Pischke, J. S. (2007). The Impact of Length of the School Year on Student Performance and Earnings: Evidence from Germany. *Economic Journal*, 117(523), 1216-1242. https://doi.org/10.1111/j.1468-0297.2007.02080.x

Rebollo-Sanz, Y. F., & De la Rica, S. (2020). Gender gaps in skills and labor market outcomes: evidence from the PIAAC. *Review of Economics of the Household*, 1-39. https://doi.org/10.1007/s11150-020-09523-w

Schaie, K. W. (2005). Developmental influences on adult intelligence: The Seattle longitudinal study. *Oxford University Press*.

Serrano, J. F. J., Lacuesta, A., Matute, M. M. y Villanueva, E. (2017). La formación del capital humano en el mercado de trabajo. *Boletín económico-Banco de España*, (4)6.

Sevilla, M.-P., & Farías, M. (2020). Labour market mismatch in emerging countries: The case of Chile. *Compare: A Journal of Comparative and International Education*, 50(2), 276-293. https://doi.org/10.1080/03057925.2019.1675495.

Shields, R., & Sandoval Hernandez, A. (2020). Mixed signals: cognitive skills, qualifications and earnings in an international comparative perspective. *Oxford Review of Education*, 46(1), 111-128. https://doi.org/10.1080/03054985.2019.1687436.

Sobiech Pellegrini, I., Chmura, R., Sawulski, J., & Mętrak, T. (2025). Can the improvements in human capital quality mitigate the negative impact of ageing on growth? Evidence from selected EU countries. *Economics of Transition and Institutional Change*, 33(2), 253-274. https://doi.org/10.1111/ecot.12430

Valenzuela Sánchez, N. A. y Palomares Vega, M. M. (2023). Análisis y evaluación de las competencias laborales en el mercado de trabajo mexicano. *LATAM Revista Latinoamericana de Ciencias Sociales y Humanidades*, 4(6), 1108-1126. https://doi.org/10.56712/latam.v4i6.1509

Vázquez Campos, J. E. y Mireles-Cárdenas, C. (2024). Pensamiento crítico y habilidades informativas: Binomio para la formación de usuarios en educación media superior en México. *Revista Estudios de la Información*, 2(2), 53–71. https://doi.org/10.54167/rei.v2i2.1688

Van Laar, E., Van Deursen, A. J. A. M., Van Dijk, J. A. G. M. & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *SAGE Open*, 10(1). https://doi.org/10.1177/2158244019900176

Villar, A. (2013). Formación y habilidades cognitivas en la población adulta española. Comparación intergeneracional de los conocimientos matemáticos a partir de los datos del PIAAC. *Instituto Nacional de Evaluación Educativa: PIAAC. Programa internacional para la evaluación de las competencias de la población adulta.*

Wiener, R. C., Waters, C., & Bastin, M. (2025). Appalachian Numeracy and Literacy and Oral Health, an Ecological Study, PIAAC and BRFSS. Journal of Public Health Dentistry. https://doi.org/10.1111/jphd.12672

Xu, X. (2024). A profile of core workplace skills in developing countries: utilizing PIAAC datasets. *Higher Education, Skills and Work-Based Learning*, 14(2), 492-509. https://doi.org/10.1108/HESWBL-09-2022-0184

Yildirim Erbasli, S. N., & Cui, Y. (2022). Cognitive Skills of Canadian Educators: An Analysis of PIAAC Data. *Alberta Journal of Educational Research*, 68(2), 234-253. https://doi.org/10.11575/ajer.v68i2.71334

Contribution Role	Author(s)
Conceptualization	Beatriz M. Terán-Pérez (principal), Norma Aida Valenzuela Sánchez (supporter)
Methodology	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Software	Not Applicable
Validation	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Formal Analysis	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Investigation	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Resources	Not Applicable
Data curation	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Writing – Preparing the original draft	Beatriz M. Terán-Pérez
Writing – Review and Editing	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Display	Beatriz M. Terán-Pérez
Supervision	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Project Management	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)
Acquisition of funds	Beatriz M. Terán-Pérez (same), Norma Aida Valenzuela Sánchez (same)