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Digital Divide to Virtual Education: Evidence from Argentina

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Abstract

COVID-19 forced an abrupt change in the teaching-learning process. From a scheme based on face-to-face teaching, we moved to a unique and exclusive system of virtual education. This change in the educational system involved forced adaptations of both students and teachers without a prior analysis of the required technological feasibility.

This work studies the problem of digital division existing in Argentina, related to the access and use of technology and infrastructure in its educational system. From an empirical point of view, it seeks to answer the following questions: are students and teachers prepared to face a virtual learning process from a technological point of view? And what variables and factors determine technological access to the virtual education process?

For this, two Virtual Education Indices are built, one aimed at students and the other at teachers, based on the access and use of PCs and mobile phones. Then, they are used to estimate a logit model for technological access for students and another for technological access for teachers.

Using data from the EPH, it is analyzed how technologically prepared students and teachers are to participate in the virtual education process, at its three levels. A Technological Index of Virtual Education is built for students and another for teachers, based on the possession of a PC and the Internet and through the use of the Internet, PC and cell phone.

The analysis reveals that students are better prepared from a technological point of view than teachers to be able to face the virtual education process.

The most important variables that positively affect the probability of having technological access to virtual education in the case of students are: the age of the student, the total family income, the education of the student's mother, work in the labor market of the mother of the student, the number of people employed within the home and the number of inhabitants of the residential area. The negative effects on the probability of technological access to virtual education come from: attendance at public education establishments, overcrowding within the home and the number of children under 10 years of age.

The probability of having technological access to virtual education in the case of teachers is positively affected by: the teacher's years of education and individual income. While the age of the teacher, overcrowding within the home and the number of inhabitants of the residential area negatively affect the probability of technological access to virtual education for teachers.

Keywords: Analysis of education; Regional analysis; Technological change

JEL Codes: I21, R50, O33

Resumen

El COVID-19 obligó a un cambio abrupto en el proceso de enseñanza aprendizaje. Desde un esquema basado en enseñanza presencial se pasó a un sistema único y exclusivo de educación virtual. Este cambio en el sistema educativo implicó adaptaciones forzadas tanto de estudiantes como de docentes sin un análisis previo sobre la factibilidad tecnológica requerida.

Este trabajo estudia el problema de división digital existente en Argentina, relacionado al acceso y uso de tecnología e infraestructura en su sistema educativo. Desde un punto de vista empírico, bisca responder las siguientes preguntas: ¿están preparados los estudiantes y docentes para enfentar un proceso de aprendizaje virtual desde un punto de vista tecnológico? y ¿qué variables y factores determinan el acceso tecnológico al proceso de educación virtual?

Para eso, se contruyen dos Índices de Educación Virtual, uno dirigido a estudiantes y otro a docents, basados en el acceso y uso de PC y de teléfonos móviles. Luego, se los utiliza para estimar un modelo logit para acceso tecnológico para estudiantes y otro para acceso tecnológico para docents.

Con datos de la EPH, se analiza cuán preparados tecnológicamente están los alumnos y docentes para participar del proceso de educación virtual, en sus tres niveles. Se construye un Índice Tecnológico de Educación Virtual para alumnos y otro para docentes, a partir de la tenencia de pc e internet y a través del uso de internet, pc y celular.

El análisis revela que los alumnos están mejor preparados desde el punto de vista tecnológico que los docentes para poder afrontar el proceso de educación virtual.

Las variables más importantes que afectan positivamente la probabilidad de tener acceso tecnológico a educación virtual en el caso de los alumnos son: la edad del alumno, el ingreso total familiar, la educación de la madre del alumno, el trabajo en el mercado laboral de la madre del alumno, el número de personas empleadas dentro del hogar y el número de habitantes del aglomerado de residencia. Los efectos negativos sobre la probabilidad de acceso tecnológico a educación virtual provienen de: la asistencia a establecimiento público de educación, el hacinamiento dentro del hogar y el número de menores de 10 años.

La probabilidad de tener acceso tecnológico a educación virtual en el caso de los docentes es afectada positivamente por: los años de educación del docente y el ingreso individual. Mientras que la edad del docente, el hacinamiento dentro del hogar y el número de habitantes del aglomerado de residencia afectan negativamente la probabilidad de acceso tecnológico a educación virtual de los docentes.

Palabras clave: Análisis de la educación; Análisis regionales; Cambio tecnológico perspectiva de género; paradoja del género; derechos de la mujer; feminismo cis y trans.

Códigos JEL: I21, R50, O33

1.- Introduction

Two facts motivate the present paper. First, educational equity is a desirable goal and requires certain conditions such as access to the educational system, addressing material inequalities inside and outside of school, providing psychological and pedagogical support to students and their families, among other possible issues.

Second, due to the Covid-19 pandemic affecting the world, much of face-to-face education at all educational levels was replaced entirely by virtual education. Covid -19 radically changed the way in which education is now offered since both school and home became the same learning place after different countries established new regulations. UNESCO estimates that 860 million children and young people, distributed in 119 countries, had to radically change their way of learning due to pandemic. Argentina is not an exception in this atmosphere of radical changes, regarding the development and implementation of virtual education. In mid-March 2020, the decision was made that the education system at all levels should adapt to virtual learning (Resolution 108/2020 from the Ministry of Education dated March 15, 2020).

Authors such as Llach and others (2006); Formichella (2010); Krüger (2013) affirm that the empirical evidence linked to the principle of "unequal treatment for unequal circumstances" in Argentina is not met, given that it is not observed that those who have less receive more, but rather the opposite occurs, as those who have more receive more. They also observe that children and adolescents belonging to the lowest socioeconomic strata are the ones who face the greatest difficulties in terms of access, retention, and completion of schooling. Krüger (2018) speaks of a segmented educational system in which students are unevenly distributed among schools based on their social background, and those with unfavorable educational demand conditions encounter unfavorable conditions in terms of educational supply, thereby widening initial inequalities.

In addition to the above, and due to the new virtual modality adopted by teaching processes in the current context, a crucial factor determining educational access is access to Information and Communication Technologies (ICTs) at home. In the works of Alderete and Formichella (2016), they highlight that for example in Argentina, "the *Seguimos Educando* platform designed by the Ministry of Education and the various forms of contact between schools and students rely mainly on tools that require adequate internet connection, and having devices such as computers, notebooks, tablets, or cell phones. Here, sources of inequality between households reappear: i) not everyone has the quality of devices necessary to carry out various school activities, considering that each type of device, as well as its age or power, offers different work possibilities; ii) the number of devices in the home may be insufficient to meet the school and work needs of all its members; iii) internet access is far from homogeneous and universal in our country, and iv) there are inequalities in access to ICTs among students that are linked to inequalities in their outcomes.” Therefore, students are different in family aspects, individual issues and factors related to the environment. These differences cause asymmetries in the access and use of technologies. A similar pattern occurs on the teachers' side.

In the same works, it is stated that the State has acknowledged these inequalities and implemented measures to eliminate the 'first digital divide,' linked to access to ICTs, such as the distribution of netbooks and tablets, or free navigation on educational platforms; however, there is also a need to eliminate or reduce the so-called 'second digital divide,' related to the use of ICTs or the ability of students to benefit from them. In this sense, households that do not have access to ICTs, have it deficiently, or do not make appropriate use of them, are in a clear situation of disadvantage.

It is in this context that the present work appears. Although new educational technologies (EdTech) have been gaining ground in recent years thanks to technological innovation, pandemic forced the world to take a huge step, without the necessary prior assessment of the ability of students (and their families) and of teachers (and their schools) to be able to face it.

This paper partially addresses the problem of the digital division existing in Argentina. A digital division exists when different obstacles prevent equal access and use of information and communication technologies (ICT). These obstacles are related to the access and use of technological and infrastructure resources, as well as their quality (eg connectivity quality) and the skills and knowledge necessary for the proper use of these technologies. It should be made clear that the availability of data allows us to make an analysis from a technical point of view. That is, we only focus on the determinants of technical access to participate in virtual education. Aspects related to quality, willingness and ability to manage, skills and knowledge necessary to operate new technologies, etc. are left out.

This paper aims to contribute to this discussion and based on the data from the EPH (Permanent Household Survey) it seeks to answer the following questions from an empirical point of view:

1. Are the students prepared to face the virtual learning process from a technical point of view?

2. What variables and factors determine technical access to the virtual learning process?

3. Are teachers prepared to face the virtual teaching process from a technical point of view?

4. What variables and factors determine technical access to the virtual teaching process?

The first two questions analyze virtual education connected to the demand, represented by 8,58 million students belonging to different levels of education. The two remaining questions focus on supply of virtual education offer of virtual education, supported by just over 800.000 teachers.

The data used in the present work is based on the EPH, more precisely from the period related to the fourth quarter of the years 2016 to 2019. We have extracted the data from households, individuals and access and use of information and communication technologies for this given period.

In order to answer the questions stated above, we used the estimation of a logit model for each part of the educational system. That is, there is a logit for technical access by students and another for technical access by teachers.

This paper is structured as follows: the context of the paper is presented in section 2. In section 3 the available data is reviewed. Section 4 presents the econometric model to be estimated, while the fifth section presents the main empirical results. Section 6 is reserved for conclusions.

2.- The context

Research related to educational technology is mainly focused on analyzing the effects of EdTech on the educational performance of students. The main argument is that the implementation of these effects would reinforce face-to-face education and compensate for deficiencies such as low teaching quality, high absenteeism, and low levels of student motivation. In addition, they would increase the flexibility and autonomy of students in relation to learning and improve attitudes and experiences of the teaching-learning process. The effects of EdTech on educational performance are varied and there is still no consensus on the causal effect of new technologies on educational performance.

a) Part of the research has revealed positive effects on the complementarity of virtual education in academic performance. Usually, the studies compare a trial group that receives computer assistance with another control group that does not receive this assistance.

- Machin et al (2007) evaluated the effects of investments in ICT (Information and Communication Technologies) in England through the use of instrumental variables and found a positive impact on student performance.
- Banerjee et al (2007) designed a randomized experiment and found that, in poor urban neighborhoods in India, the use of a computer-assisted learning program has a positive and significant effect on mathematics outcomes.
- Linden (2008) evaluated, a new computer-assisted learning program and its effectiveness in India by explicitly taking existing resources in the classroom when implementing the intervention. She found that the implementation method matters significantly to the effectiveness of the program. When implemented as a substitute for regular inputs within school hours, the program is less productive, and students learn less than they would otherwise. When implemented as a complement to existing supplies, and outside school hours, you find the program to be generally effective.
- Spieza (2010) analyzed the impact of new technologies in the PISA 2006 tests for every country taking part in the secondary school level. He found that the use of these technologies at home is more effective than their use at school and, therefore, it questions every policy aimed at incorporating computers in the school environment.
- Botello and Rincón (2014) analyze data from some Latin American countries and found that home access to internet improves student´s performance, while having computers also does so and to a greater extent. They also found that educational outcomes are better the higher the school's computer-to-student ratio.

- Bettinger et. Al. (2020) conducted an experiment in Russia to study the effects on of 6,000 third graders´ school performance in 343 schools in two provinces. A group of students is was given 45 minutes per week of computer-assisted learning as a complement of their face-to-face classes, another group is was granted 90 minutes and a third control group didn´t participate in computer-assisted learning. Based on the analysis, they estimated the educational production function in for computer-assisted learning. They found positive effects of from the use of computers s in the mathematics area, but less effects in the area of language. Their findings suggest that computer-assisted learning improves academic performance but that too much substitution could be a mistake because the production function appears to have a sharply decreasing marginal rate of substitution.

b) There are several studies that find no evidence that complementarity improves educational outcomes.

- Angrist and Lavy (2002), evaluated a program to increase the availability of computers in schools in Israel. The authors concluded that the use of computer tools in the teaching-learning processes has significant and negative effects on maths results for fourth-grade students, while they do not observe significant effects on the educational achievements of other skills in higher grades.
- Goolsbee and Guryan (2002) evaluated a program for the USA designed to subsidize school use of the Internet. They find found no effect on student's performance.
- Leuven et al (2007) evaluated the effect of computer use in the Netherlands and found results similar to those of Angrist and Lavy (2002). They proved that there are no positive effects on student´s performance in Dutch schools when applying a subsidy policy for PC and software.
- Muñoz et al (2014) studied the Chilean case and find proved that the programs to incorporate the use of ICT didn´t have significant effects on educational attainment.
- Alderete et al (2017), studied the Spanish case and estimated a Structural Equations Model (SEM) based on PISA data from 2012. They found that access to ICT at home had a significant and positive impact on the educational performance that is enhanced by the use of ICT outside of school. On the contrary, the access and use of ICT in schools had a significant and negative impact on educational achievement.
- Formichella et al. (2015), analyzed the Argentine case using matching techniques to control the various personal, family and school characteristics of Argentine high school students. By Comparing groups based on access to pc and internet at home, they concluded that the availability of ICT at home not only increases educational performance, but also decreases school failure.
- Alderete and Formichella (2016) corroborated that there are statistically significant differences in average educational performance derived from participating in the "Conectar Igualdad" program in Argentina.

This work, in its first stage, contributes to the aforementioned debate by analyzing the feasibility from the technical point of view of moving towards a complete substitution of virtual education for face-to-face education. Precisely, what is happening at present is the sudden transition from a predominantly face-to-face system to a completely virtual system, so the first fundamental step is to study technical feasibility.

That is, we will place ourselves in the previous step to the analysis of the effects of EdTech on educational performance. In order to do this, the two parts of the educational system will be examined: students and teachers.

A second stage of this line of research, but which is not part of the present work, is to analyze the effects of EdTech on the performance of students in Argentina. In order to do this, it will be necessary to analyze other sources of information such as the "*Pisa Test*" or the "*Aprender Test*".

Among the studies that analyze the technical feasibility of accessing new technologies, the following stand out:

- Underwood et al. (2005) conclude that broadband in the United Kingdom is changing the way students learn, how teachers deliver their courses, and how schools manage their activities.
- Dudek (2007) analyzed the determinants of household internet access in Poland. He used a probit model and took into account the head of household attributes and characteristics related to them (household size, age group, educational level, income level, etc.). He found that the age of the household head and the number of children have no impact on internet access. Access probability is strongly affected by income and by a higher level of education given by the household head. Cities that are larger in size have a positive impact on internet access as well as children´s age. Instead, the gender of the household head has a negative influence in the case of women.
- Davidson and Santorelli (2010) conclude that in the United States, in the long term, wireless broadband and mobile devices will likely become the primary vehicles for delivering educational content, allowing for access anytime and anywhere, and a more personalized learning process.
- Narodowski, et al. (2020) analyzed the different types of devices and media used by Argentine students in order to keep the pedagogical bond during quarantine. A survey applied to 262 families of urban primary schools in different cities of Argentina revealed that: i) WhatsApp, PDF and Word files are mostly used to give out school tasks. ii) 56% of the students use their mobile phones as the only way to obtain school connection educational connection tool and 66% of the students use a mobile phone that belongs to another family member or a third party in order to be able to follow virtual lessons. iii) 60% of students connect to the internet via Wi-Fi or broadband connection.

It is important to highlight the effort being made in Argentina to reduce the technological gap and improve educational performance. Claus and Sánchez (2019) show that data on educational investment made at the national level indicates a 13.3% real growth between 2012 and 2015, a period during which various educational policies were implemented such as "*Conectar Igualdad*", teacher training initiatives, infrastructure improvements, among others. The year 2017 stands out for a general increase in the educational budget, with a significant recovery in investment in technical education, while in 2018 there is a noticeable impact on the educational budget with a decreasing trend in major budget programs like digital education, school infrastructure, national co-financing of provincial teacher salaries, and "*Progresar*" scholarships. As a result of these and other variations in the financing of different budget programs, there was a 9% decline in national educational investment in real terms between 2016 and 2018. The authors state that in the case of the provinces, educational investment decreased by 8% between 2015 and 2016, and remained practically constant between 2016 and 2017.

During the pandemic, some actions were developed aimed at maintaining pedagogical continuity at a distance, compensating for the lack of resources and skills of many teachers, principals, and students: the "*Seguimos Educando*" platform was made available, where educational material is offered for levels from Early Childhood to Secondary and guidelines are provided for teachers to prepare virtual classes; free access to classic books was offered through the "Digital Library"; free access to training courses and materials for the development of virtual classes was provided, and notebooks and tablets were distributed, with their distribution being handled by local governments and targeted to students in public schools.

Additionally, partnerships were established with international organizations such as UNICEF to ensure access to and sustainability of technological infrastructure in schools and for the joint production of notebooks for children and adolescents in socially vulnerable contexts; or with companies like Globant and Acámica, which donated online courses to the "*Seguimos Educando*" platform.

3.- Data

Data used in the present work is based on the EPH, more precisely on the wave related to the fourth quarter of the years 2016 to 2019. As a result, we have the data for households, individuals, access and use of information and communication technologies.

It is therefore possible to extract different relevant descriptive statistics from the conjunction of the three databases (Households, Individuals and Technologies) such as the following[1]:

PC ownership and internet access at household level

Regarding access and use of ICTs applied to households, PC possession and access to the Internet was checked. The main indicators are presented below.

Table 1 shows what is related to Internet accessibility and PC ownership at household level in Argentina. The magnitudes and percentages are presented for all households and for those households that have at least one student in the educational system (Target Household).

[1] Other relevant statistics are available upon request.

Table 1: Possession of a PC and Internet access - Number and Percentage of households

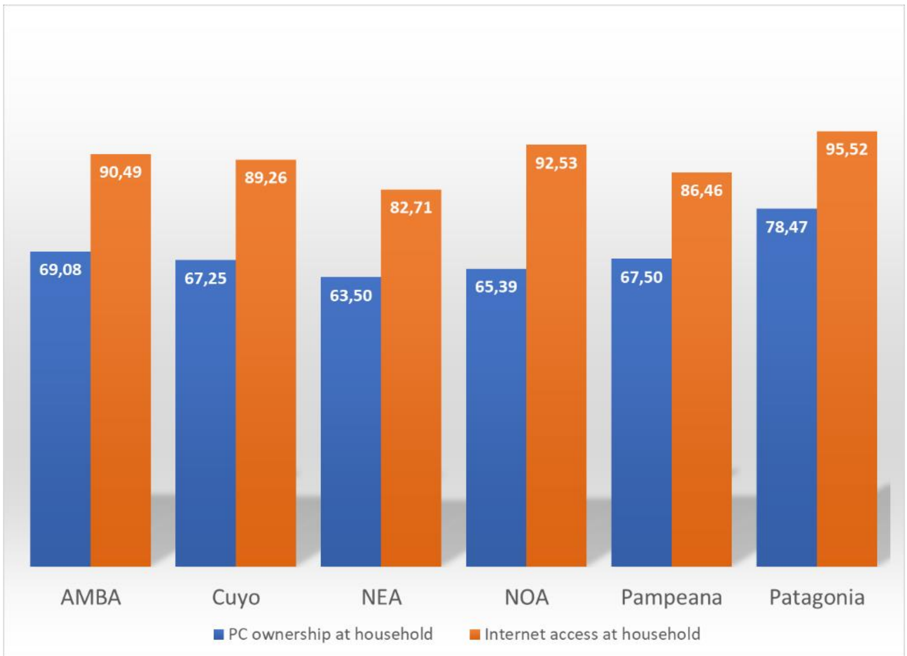
	2016	2017	2018	2019
Households				
With PC	5.826.709,0 (65,96%)	5.740.760,0 (64,35%)	5.788.054,0 (63,03%)	5.775.873,0 (60,91%)
With internet access	6.339.570,0 (71,76%)	6.780.086,0 (76,00%)	7.376.970,0 (80,34%)	7.859.122,0 (82,88%)
Target households				
With PC	3.408.043,0 (75,83%)	3.305.214,0 (74,62%)	3.324.988,0 (71,94%)	3.244.739,0 (68,31%)
With internet access	3.643.975,0 (81,07%)	3.776.418,0 (85,26%)	4.075.138,0 (88,18%)	4.251.277,0 (89,49%)

Source: own elaboration from EPH

It can be noticed that in 2019 a total of 9,48 million households is the expansion factor of the EPH. Out of these, 50,1% have a student in the educational system. In this target group, which is where the virtual education applicants would presumably be, 68% have access to a PC and 89% have access to the internet.

Graph 1 shows the distribution by regions in terms of PC ownership and internet access for the target households. It is observed that the percentage with internet access is higher than the percentage of PC ownership in all regions of the country. The NEA region is the one with the lowest PC ownership and internet access in the country. Patagonia is the region with the highest percentages in both items.

Graph 1: PC ownership and Internet access by Region - 2019 - Target Household



Source: own elaboration from EPH

Table 2 shows the percentage of PC ownership and internet access according to the household income decile. Since 2016, it has been observed that as the household increases the income decile from 1 to 10, the percentage of households that have a PC and Internet access at home increases. In 2019, 34.49% of the households that are in the poorest decile have a PC and 71.90% have internet access. These figures grow as the household increases in decile. 95.86% of the highest income decile have a PC while 97.07% have internet access.

Table 2: Possession of a PC and Internet access by income decile - Target Household

	2016	2017	2018	2019
With PC		Porcentage by decil		
1	49,9	48,9	42,4	34,5
2	56,9	60,8	49,7	49,8
3	67,0	60,4	57,4	49,5
4	69,8	67,1	60,4	60,7
5	72,5	70,4	67,1	61,2
6	72,7	73,8	72,7	70,0
7	79,2	80,6	78,8	78,2
8	87,1	88,2	83,9	83,0
9	86,4	89,3	89,7	90,5
10	96,7	93,9	96,1	95,9
With Internet access				
1	57,5	66,1	68,9	71,9
2	68,2	78,2	73,5	80,5
3	72,4	76,3	84,8	79,2
4	77,4	84,2	84,8	89,0
5	78,4	83,2	88,6	87,0
6	78,7	86,0	88,8	90,4
7	84,4	88,7	94,5	96,7
8	91,4	94,2	95,5	97,7
9	91,9	93,0	95,7	97,6
10	97,1	96,3	97,8	99,1

Source: own elaboration from EPH

Use of PC, internet and mobile phone at individual level

Regarding access and use of ICTs applied to individuals, the use of PC, internet and mobile phones were checked. The main indicators are presented below.

Table 3 shows everything related to the use of PC´s, internet and mobile phones which are used on an individual scale in Argentina. The magnitudes and percentages are presented for all individuals and for students who are in the educational system (Target Individual).

Table 3: Use of PC, internet and cell phone - Number and Percentage of individuals

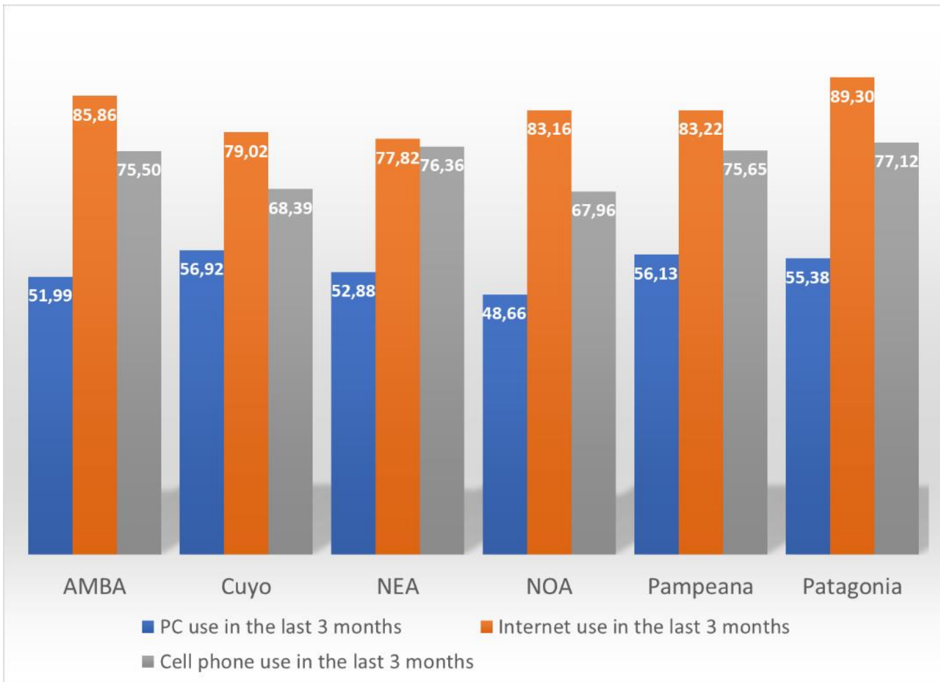
	2016	2017	2018	2019
Individuals				
Used PC in the last three months	11.972.682,0	11.538.919,0	11.233.278,0	11.201.747,0
	(46,55%)	(44,84%)	(42,62%)	(41,41%)
Used internet in the last three months	18.251.131,0	19.128.804,0	20.472.066,0	21.626.906,0
	(70,97%)	(74,33%)	(77,68%)	(79,94%)
Used cell phone in the last three months	20.303.674,0	20.906.176,0	22.008.535,0	22.794.903,0
	(78,95%)	(81,24%)	(83,51%)	(84,26%)
Target individuals				
Used PC in the last three months	4.803.932,0	4.542.613,0	4.483.730,0	4.453.978,0
	(61,91%)	(58,39%)	(55,16%)	(53,01%)
Used internet in the last three months	6.322.469,0	6.374.595,0	6.831.083,0	7.081.235,0
	(81,48%)	(81,94%)	(84,03%)	(84,27%)
Used cell phone in the last three months	5.260.924,0	5.591.627,0	5.994.188,0	6.250.530,0
	(67,80%)	(71,87%)	(73,74%)	(74,39%)

Source: own elaboration from EPH

It can be seen that in 2019 a total of 27.05 million individuals is the expansion factor of the EPH. Out of these, 31.7% are students belonging to the educational system. In this target group, 53% used a PC in the last 3 months, 84.3% used the internet in the last months and 74.4% used a cell phone in the last 3 months. When we analyze the evolution throughout this period, an increase in the percentage of internet use (+ 2.79%) and cell phones (+6.59) is observed, but we notice a decrease in the use of PCs (-8, 9%).

Graph 2 shows the distribution by regions in terms of devices and internet use for the target group. It is observed that the percentage of internet use is higher than the other percentages of use in all regions of the country. Internet use finds its maximum value in Patagonia and its minimum value in the NEA (northeastern of Argentina). The use of PCs has its maximum value in Cuyo, while the use of cell phones stands out in Patagonia.

Graph 2: Use of PC, Internet and Cellular by Region - 2019 - Target Individual



Source: own elaboration from EPH

Distribution of students by type of educational establishment

Table 4 shows the situation by type of educational establishment attended by students. It is observed that, in 2019, 73.7% of students attended a public establishment and 26.2% attended a private establishment. Attendance at public establishments has been increasing from 2017 onwards. Table 5 shows the distribution by region. Attendance at public education establishments reaches its maximum in Patagonia and NEA (northeastern of Argentina) and its minimum in AMBA (Buenos Aires Metropolitan Area).

Table 4: Distribution of students by type of educational establishment

	2016	2017	2018	2019
Type of educational establishment				
Total	7.971.029,0	8.086.915,0	8.344.373,0	8.583.979,0
Public	5.845.441,0 (73,33%)	5.774.749,0 (71,41%)	5.995.591,0 (71,85%)	6.326.319,0 (73,70%)
Private	2.104.793,0 (26,41%)	2.298.498,0 (28,42%)	2.347.346,0 (28,13%)	2.247.927,0 (26,19%)
NS/NR	20.795,0 (0,26%)	13.668,0 (0,27%)	1.436,0 (0,02%)	9.733,0 (0,11%)

Source: own elaboration from EPH

Table 5: Distribution of students by type of educational establishment and region Year 2019

	Total	AMBA	CUYO	NEA	NOA	PAMPEANA	PATAGONIA
Type of educational establishment							
Total (Year 2019)	7.971.029,0	4.557.498,0	541.737,0	449.031,0	896.203,0	1.824.816,0	314.694,0
Public	6.326.319,0	3.151.023,0	419.922,0	379.667,0	707.471,0	1.398.215,0	270.021,0
	(73,70%)	(69,14%)	(77,51%)	(84,55%)	(78,94%)	(76,62%)	(85,80%)
Private	2.247.927,0	1.400.013,0	121.815,0	69.364,0	188.276,0	423.786,0	44.673,0
	(26,19%)	(30,72%)	(22,49%)	(15,45%)	(21,01%)	(23,22%)	(14,20%)
NS/NR	9.733,0	6.462,0	-	-	456,0	2.815,0	-
	(0,11%)	(0,14%)	(0,00%)	(0,00%)	(0,05%)	(0,15%)	(0,00%)

Source: own elaboration from EPH

4.- Empirical model

This section presents the econometric model that will be used to determine the conditions that affect people's access to virtual education.

The theoretical model that we have in mind is a latent variable index model like the following:

$$ITEVI_i^* = f\{(individual\ characteristics_i)(household\ characteristics_i)\ (environment_i,)\} \quad (1)$$

Where ITEVI=1 if ITEVI*>0.

That is, it is observed whether person i has the technical conditions to access virtual education (ITEVI = 1) or does not have them (ITEVI = 0). This implies that we have a binary dependent variable. But the decision to have technical accessibility to virtual education or not would depend on a rational behavior, which cannot be observed by the econometrician. If the net utility of the agent (unobservable) is positive (ITEVI *> 0) then the individual will have technical accessibility, but if it is negative (ITEVI * <0), the person will decide not to have the conditions to have access to virtual education.

ITEVI is a Technical Index of Virtual Education that is obtained from the questions made for Access and Use of Information Technologies Module of the EPH. Out of five questions that have to do with internet access, pc access (from home) and internet use, pc use and cell phone use (applied to the individual) we are able to determine the different situations that enable students to have access to full virtual education.

Depending on the case, we will have:

• ITEVIa: Technical Index of Virtual Education for students.

• ITEVId: Technical Index of Virtual Education for teachers.

The ITEVId raises a much more restrictive criteria since the teacher requires better conditions to be able to develop virtual education. That is, preparing classes, student guides, simulations, grading exams, etc. imply much more demanding conditions from the technical point of view in order to participate in virtual education.

In the Annex, the construction of both ITEVIs is presented from the 32 possible situations that can occur from the 5 base questions (25 = 32), both for students and teachers.

The students who have an ITEVI = 1 are the following:

• They have internet and they have a pc.

• They have internet and use a PC or cell phone.

• They do not have internet at home, but they use the internet individually either on PC or cell phone (use).

The students who have an ITEVI = 0 are the following:

• They have internet and they don't have a PC and they don't use a PC or cell phone (Netflix).

• They do not have, nor do they use the internet.

Teachers who have an ITEVId = 1 are those who have possession and use of the internet as well as a computer.

We assume that people's net income depends on individual variables, characteristics household characteristics and the environment. Suppose for the moment that there are no endogeneity problems and that the respective equations are correctly specified.

Equation to estimate in the case of the students

We consider all students who are attending an educational establishment, regardless of their level. That is, they are people who are studying some educational level (primary, secondary, post-secondary or university). In the 2019 EPH, 30.6% of the respondents met this characteristic. This implies that there is information about 17,896 individuals representing 8.58 million people from the main conglomerates in the country.

The distribution regarding technical access to virtual education for students (ITEVIa) is presented in table 6.

Table 6: Distribution of students according to ITEVIa by region - Year 2019

	Total	AMBA	CUYO	NEA	NOA	PAMPEANA	PATAGONIA
Technical Access to Virtual Education							
Total (Year 2019)	8.583.979,0	4.557.498,0	541.737,0	449.031,0	896.203,0	1.824.816,0	314.694,0
NO	1.218.517,0	612.660,0	87.907,0	82.297,0	144.917,0	262.629,0	28.107,0
	(14,20%)	(13,44%)	(16,23%)	(18,33%)	(16,17%)	(14,39%)	(8,93%)
YES	7.365.462,0	3.944.838,0	453.830,0	366.734,0	751.286,0	1.562.187,0	286.587,0
	(85,80%)	(86,56%)	(83,77%)	(81,67%)	(83,33%)	(85,61%)	(91,07%)

Source: Authors' calculations

The analysis of Table 6 allows us to answer the first question posed in the introduction. How prepared are students from a technical point of view to be able to face the virtual learning process?

85.8% of the students in Argentina have the technical conditions to be able to participate in the virtual learning process. However, there are significant disparities between regions. While in the NEA 18.3% of the students do not have the technical conditions to be able to participate in virtual education, that percentage in Patagonia is only 8.9%.

Inequalities in technical access to virtual education are aggravated when we compare conglomerates. Thus, while in CABA only 2.9% of students do not have the possibility to participate in virtual education, that percentage rises to 30.6% in San Juan and 37.2% in Santiago del Estero.

In other words, in general terms, virtual education on the side of the students, has an important coverage in order to be able to participate in the virtual learning process, but facts among regions and clusters are very different.

In order to answer the second question posed in the introduction, we have to analyze which variables determine whether or not a student has technical access to virtual education. The basic econometric model that arises is the following:

$$ITEVI_a = \beta_0 + \beta_1 age_a + \beta_2 age_a^2 + \beta_3 educ_a + \beta_4 educ_a^2 + \beta_5 educ\_pub_a + \beta_6 itf\_m_h + \beta_7 perhab_h + \beta_8 educmuj\_hog_h + \beta_9 trabmuj\_hog_h + \beta_{10} n\_emphog_h + \beta_{11} n\_menor10_h + \beta_{12} n_{hab} + \varepsilon_i \quad (2)$$

Where:

- ITEVIa: is the Technical Index of Virtual Education for students described above. It is a dummy variable.
- age: is the student´s age. In order to capture non-linearities, a squared component is also added. The effect of age on technical access to virtual education is expected to be positive at a decreasing rate, that is, β1> 0 and β2 <0. That is, the older the age, the greater the possibilities of being able to take full advantage of virtual education, either through the possibility of access to devices, platform use, links with other students, etc. However, this effect could suffer the law of diminishing returns, therefore, the concavity issue raised at the beginning.
- educ: are the years of education of the student. The same effects as in the case of age, are expected, that is, β3> 0 and β4 <0. The higher the level of education, the greater the possibilities of being able to take advantage of virtual education, either through the possibility of accessing more complex platforms or through the use of modern devices. The existence of diminishing returns is proposed for this variable. [2]
- educ_pub: is a dummy variable that indicates whether the student attends a public educational establishment. It is expected that β5 <0, this is because access to virtual education would require previous investments at home (such as internet and PC ownership). If the students with less economic possibilities are biased towards public education, as indicated by various studies carried out, then they should show less possibilities of having technical access to virtual education.

[2] This variable would be correlated with age in those individuals who have to complete a compulsory education (primary and secondary) and are up to date with their studies. However, repetition and differential initiation in preschool introduce differentiations. At the university level, the decoupling is more evident, due to the delays that occur in the completion of the careers.

- itf_m: is the total family household income in which the student lives. It is measured in thousands of pesos. It is expected that technical access to virtual education is positively correlated with family income level, therefore, $\beta6 > 0$. This is based on the minimum investments required to have access to virtual education (connectivity, devices, data packages, etc.).
- perhab: represents the number of people per room within the house. The more people per environment, the greater the discomfort to be able to comply with virtual education, therefore, the less likely it is to have access to it. Given this, it is expected that $\beta7 < 0$. This variable is a proxy for overcrowding towards the interior of the home.
- educmuj_hog: indicates the amount of years the female head of household (or spouse) has received education. In most observations it represents the mother's years of education. It is expected that more educated mothers have a greater appreciation of the educational process, therefore, they make greater efforts to be able to provide technical home accessibility to develop virtual education. That is, we expect that $\beta8 > 0$.
- trabmuj_hog: is a dummy variable that indicates whether the female head of household (or spouse) works outside home. It is a very good proxy for the mother's employment status. In this variable, there are two opposite effects that can be analyzed. On the one hand, if the mother works, she has more income and therefore she can make investments in virtual accessibility ($\beta9 > 0$). But on the other hand, she would have less time to help her children in the development of virtual education so that $\beta9 < 0$. This effect is very important especially in primary school students. The opposite magnitude of these two effects is that it will determine the final effect of this variable on the technical index of virtual education.
- n_emphog: indicates the number of people in the household who work in the labor market. This variable has similar considerations as the previous one. That is, on the one hand, the more people in the household work, the higher the income obtained, therefore there would be a positive impact on the ITEVI ($\beta10 > 0$). But on the other, there would be fewer people available at home to help with virtual education ($\beta10 < 0$). The magnitude of these opposing effects will determine the final effect of the variable on the ITEVI.
- n_menor10: indicates the number of people under the age of 10 living in the household. It is expected that, in households with a greater presence of younger children, access to virtual education will be lower ($\beta11 < 0$). This is because connectivity and the use of devices would have a more positive impact on older people.
- n_hab: indicates the number of inhabitants of the conglomerate where the student resides. It is measured in thousands of inhabitants and captures the effects of the environment on virtual education. Larger cities are expected to have greater connection possibilities, therefore, greater possibilities of having virtual education ($\beta12 > 0$). Unfortunately, the available data does not allow us to capture effects such as rural or small towns. This is because the EPH takes place in major cities of the country.

Equation to estimate in the case of teachers

In this section, we consider all those people who carry out occupations related to education, more precisely teaching. In the 2019 EPH, 2.85% of respondents meet this characteristic. This implies that there is information for 1,666 individuals representing just over 811,000 teachers from the main conglomerates in the country.

The distribution regarding technical access to virtual education for teachers is presented in table 7.

Table 7: Distribution of teachers according to ITEVId by region - Year 2019

	Total	AMBA	CUYO	NEA	NOA	PAMPEANA	PATAGONIA
Technical Access to Virtual Education							
Total (Year 2019)	811.260,0	440.114,0	54.789,0	41.972,0	76.492,0	170.115,0	27.778,0
NO	191.627,0	117.212,0	11.410,0	8.690,0	16.281,0	32.515,0	5.519,0
	(23,62%)	(26,63%)	(20,83%)	(20,70%)	(21,28%)	(19,11%)	(19,87%)
YES	619.633,0	322.902,0	43.379,0	33.282,0	60.211,0	137.600,0	22.259,0
	(76,38%)	(73,37%)	(79,17%)	(79,30%)	(78,72%)	(80,89%)	(80,13%)

Source: Authors' calculations

The analysis of Table 7 allows us to answer the third question posed in the introduction. How prepared are teachers from a technical point of view to face the virtual teaching process?

76.4% of teachers in Argentina have the optimal technical conditions to be able to participate in the virtual teaching process. However, there are significant disparities between regions. While in the AMBA 26.6% of the teachers do not have the optimal technical conditions to be able to participate in virtual education, that percentage in the Pampeana region is 19.1%.

Inequalities in technical access to virtual education are aggravated when we compare conglomerates. Thus, while in Río Cuarto only 3% of teachers do not have the possibility of participating in virtual teaching, that percentage rises to 40.8% in Neuquén.

That is to say, in general terms, virtual education supply has important limitations to be able to participate in the virtual teaching process. However, the realities among regions and conglomerates are very different.

To answer the fourth question posed in the introduction, we need to analyze which variables determine whether or not a teacher has technical access to virtual education. The basic econometric model we have in mind is the following:

$$\begin{aligned} ITEVI_d &= \beta_0 + \beta_1 age_d + \beta_2 educ_d + \beta_3 est\_pub_d + \beta_4 iti\_m_d \\ &+ \beta_5 perhab_h + \beta_6 n\_emphog_h + \beta_7 n\_integ\_hog_h + \beta_8 n\_hab + \varepsilon_i \qquad (3) \end{aligned}$$

Where:

- ITEVId: is the Technical Index of Virtual Education for teachers described above. It is a dummy variable.
- age: is the teacher´s age. The effect of age on technical access to virtual education is expected to be negative, that is, $\beta 1 < 0$. In other words, the older the teacher, the lower the possibilities of being able to fully develop virtual education. This is because older teachers would be more reluctant to participate in it and would have more difficulties to carry it out. However, not having any measure of the quality of virtual education, it is likely that teachers have technical access to develop it, but the adjustments are given in certain aspects of its quality (a characteristic that is not possible to observe with our available data).
- educ: are the years of teacher´s education. A positive effect of years of education is expected on technical access to virtual education ($\beta 2 > 0$). The higher the level of education, the greater the possibilities of being able to take advantage of virtual education, either through the possibility of accessing more complex platforms or through the use of more modern devices.
- est_pub: is a dummy variable that indicates whether the teacher works in a public establishment. If it were verified that teachers in private schools have a higher salary than teachers in public schools and given that access to virtual education would require previous investments at home (such as internet and PC), it would be expected that $\beta 3 < 0$.
- iti_m: is the total individual income of the teacher measured in thousands of pesos. Technical access to virtual education is expected to be positively correlated with the teacher's income level, therefore, $\beta 4 > 0$. This is based on the minimum investments required to have access to virtual education (connectivity, devices, data packages, etc.).
- perhab: represents the number of people per room within the home. The more people per room, the greater the discomfort to be able to comply with virtual education, therefore, the less likely it is to have access to it. Given this, it is expected that $\beta 5 < 0$. This variable is a proxy for overcrowding towards the interior of the home.
- n_emphog: indicates the number of people in the teacher's household who work in the labor market. The more people in the household who work, the higher the income obtained, therefore, there would be a positive impact on the ITEVId ($\beta 6 > 0$).
- n_integ_hog: indicates the number of people living in the teacher's home. It is expected that, in households with a greater number of members, access to virtual education will be higher ($\beta 7 > 0$). This is because connectivity and the use of devices would be an incentive to devote more time to leisure activities.
- n_hab: indicates the number of inhabitants of the conglomerate where the teacher resides. It is measured in thousands of inhabitants and captures the effects of the

environment on virtual education. Larger cities are expected to have greater connection possibilities, therefore, greater possibilities of having virtual education ($\beta 8 > 0$). [3].

As can be seen on both sides of the market, both for the students and teachers, the dependent variable is a dummy. According to the type of error ε that we assume, we can estimate a probit model if we assume that it is normally distributed, or a logit model if we assume that it is logistically distributed. It should be noted that both methods use maximum likelihood. In this case, we estimate a logit model, both for students and teachers.

5.- Empirical evidence

In this section is the empirical results that arise from estimating the econometric equations shown above. In both cases, the estimation of a logit model is applied.

In the case of the students and teachers, the order of presentation will be the same. First of all, the matrix of estimated coefficients is presented, which will allow us to determine which variables are significant. Second, the marginal changes for each of the variables are analyzed. In the case of discrete variables we analyze the derivative and in the case of continuous variables we analyze the elasticity. Finally, we present indicators in order to determine if the model we chose was appropriate.

All relevant indicators for the waves from 2016 to 2019 are presented, but when we proceed to analyze, we will focus on 2019 as it is the most current information available.

A. Case of students

Matrix of estimated coefficients

Table 8 shows the estimated coefficients of the variables together with the probability of rejection of the statistic Z (P>z) [4].

[3] Unfortunately, the available data do not allow us to capture effects such as rurality or small towns. This is because the EPH takes place in major cities of the country.

[4] Since logit is used as a maximum likelihood estimation method, which is generally applied to large samples, the estimated standard errors are asymptotic. Given this, instead of using the t statistic to evaluate the statistical significance of a coefficient, the Z statistic (standardized normal) is used. The inferences are based on the normal table.

Table 8: Logit Estimators for students

Variable	2016 Coef	(p-value)	2017 Coef	(p-value)	2018 Coef	(p-value)	2019 Coef	(p-value)
age	0,0619	(0.00)	0,0672	(0.00)	0,0785	(0.00)	0,0980	(0.00)
age2	-0,0013	(0.00)	-0,0012	(0.00)	-0,0013	(0.00)	-0,0016	(0.00)
educ	0,0197	(0.36)	0,0203	(0.39)	0,0257	(0.31)	0,0283	(0.22)
educ2	0,0083	(0.00)	0,0088	(0.00)	0,0121	(0.00)	0,0078	(0.00)
educ_pub	-0,8258	(0.00)	-0,7912	(0.00)	-0,9354	(0.00)	-1,0609	(0.00)
itf_m	0,0273	(0.00)	0,0213	(0.00)	0,0209	(0.00)	0,0146	(0.00)
perhab	-0,1534	(0.00)	-0,2070	(0.00)	-0,1956	(0.00)	-0,2896	(0.00)
educmuj_hog	0,1031	(0.00)	0,0895	(0.00)	0,1026	(0.00)	0,0815	(0.00)
trabmuj_hog	-0,0248	(0.65)	0,0364	(0.53)	-0,0859	(0.16)	0,1026	(0.08)
n_emphog	0,0884	(0.00)	0,0796	(0.00)	0,1582	(0.00)	0,0529	(0.06)
n_menor10	-0,2393	(0.00)	-0,2272	(0.00)	-0,1501	(0.00)	-0,1951	(0.00)
n_hab	0,0000	(0.69)	0,0000	(0.00)	0,0000	(0.30)	0,0000	(0.01)
_cons	0,4535	(0.00)	0,7487	(0.00)	0,2453	(0.12)	0,7118	(0.00)
N	17466		17410		17289		17896	
LR chi2(12)	2764,09		2782,66		3096,68		3380,10	
Prob > chi2	0		0		0		0	
Pseudo R2	0,1838		0,2022		0,2341		0,2335	

Source: Authors' calculations

Analyzing the data for the year 2019, it can be seen that:

- There are a total of 17,896 students participating in the 2019 survey.
- All coefficients are statistically significant at 95% except for the one that measures student's education. The coefficient that captures the variable related to the work of the female head of family is significant, but at 90%. A similar structure is observed for the previous years.
- The coefficients that measure the effect of student's age on technical access to virtual education is positive but decreasing. That is, each additional year of the student increases the probability of having technical access, but at a decreasing rate. This is consistent with previous expected effects.
- Student´s years of education do not influence technical access to virtual education. This is not consistent with what was initially proposed.
- The coefficient that measures the effect of attendance at a school is negative. In other words, public school students are less likely to have technical access to virtual education. This would be in accordance with the effect expected a priori.

- ITF coefficient is positive, which implies that students with a higher total family income have a greater probability of technically accessing virtual education. This effect is consistent with expectations.
- The number of people per room (overcrowding proxy) has a negative effect on technical access to virtual education. Homes with more overcrowding are less likely to have technical accessibility to virtual education which is compatible with what is expected a priori.
- The coefficient related to the years of education of the head of the household (or spouse) is positive. Students who have a mother (household head or spouse) with a higher education have a greater probability of having access to virtual education which was expected a priori.
- The coefficient related to the fact that the household head is part of the labor market is positive, but slightly significant. This would indicate that students who have a working mother (household head or spouse) have a greater probability of having technical access than those students whose mother carries out household activities. Apparently, income effect would be greater than the aid effect in this case.
- The number of people in the student's household who work has a positive effect on connectivity. Students who live in households with a greater number of members in the labor market have a greater probability of technical access to virtual education than those students who reside in households with fewer income generators. Apparently, the income effect would be greater than the aid effect in this case.
- The coefficient related to the number of children under 10 years of age in the household is negative. The greater the number of children under 10 years old, the lower the probability of having technical access to virtual education. This is consistent with what was previously expected.
- The coefficient that measures the impact of the number of inhabitants of the conglomerate is positive. Students residing in larger clusters have a greater probability of having access to virtual education. This is consistent with what was previously expected.
- The likelihood ratio statistic is very high (3380.1), so the null hypothesis that all slope coefficients are simultaneously equal to 0 is rejected.
- Pseudo R2, which measures the goodness of fit in the logit model, establishes that together the independent variables are statistically significant at an approximate level of 23.4%.

Marginal changes

The logit coefficients allow us to analyze the direction of the effects, but not their magnitude. Now we focus on the marginal changes that occur when the different independent variables are modified, which will give us a better idea of their interpretation.

Table 9 shows the marginal changes. The discrete variables we will analyze their derivative, while the continuous variables we will analyze them in terms of elasticity.

Table 9: Marginal Changes in Logit for students

Variable	2016 Efecto marginal	(*p*-value)	2017 Efecto marginal	(*p*-value)	2018 Efecto marginal	(*p*-value)	2019 Efecto marginal	(*p*-value)
age	0,0067	(0.00)	0,0064	(0.00)	0,0070	(0.00)	0,0093	(0.00)
age2	-0,0001	(0.00)	-0,0001	(0.00)	-0,0001	(0.00)	-0,0001	(0.00)
educ	0,0021	(0.36)	0,0019	(0.39)	0,0023	(0.31)	0,0027	(0.22)
educ2	0,0009	(0.00)	0,0008	(0.00)	0,0011	(0.00)	0,0007	(0.00)
educ_pub	-0,0897	(0.00)	-0,0758	(0.00)	-0,0837	(0.00)	-0,1008	(0.00)
itf_m	0,0466	(0.00)	0,0438	(0.00)	0,0493	(0.00)	0,0571	(0.00)
perhab	-0,0546	(0.00)	-0,0639	(0.00)	-0,0571	(0.00)	-0,0976	(0.00)
educmuj_hog	0,0112	(0.00)	0,0086	(0.00)	0,0092	(0.00)	0,0077	(0.00)
trabmuj_hog	-0,0027	(0.65)	0,0035	(0.53)	-0,0077	(0.16)	0,0098	(0.07)
n_emphog	0,0096	(0.00)	0,0076	(0.00)	0,0142	(0.00)	0,0050	(0.06)
n_menor10	-0,0260	(0.00)	-0,0218	(0.00)	-0,0134	(0.00)	-0,0185	(0.00)
n_hab	0,0000	(0.69)	0,0000	(0.00)	0,0000	(0.30)	0,0000	(0.01)

Source: Authors' calculations

Analyzing the data for the year 2019, it can be seen that:

- An additional year of student age is associated with a 0.9% increase in the probability of having technical access to virtual education. But the effect of age on the probability of access is decreasing, as shown by the marginal change associated with the square of age.
- Increasing one year of student education does not make an impact on the probability of technical access to virtual education.
- If the student attends a public school, she is 10% less likely to have access to virtual education (compared to the one who attends a private school). This marginal change increased in the 2016-2019 period by just over 1 percentage point.
- If the total family income of the student increases by 1%, the probability of having technical access to virtual education increases by 5.7%. This effect registered an increase in the period analyzed.
- When the number of people per room increases 1%, the probability of access to virtual education is reduced by 9.7%.
- An additional year of education for the student's mother is associated with a 0.77% increase in the probability of having technical access to virtual education. This effect was very relevant in 2016, when it reached 1.12%.

- If the student has a mother who belongs to the labor market, then she is 0.9% more likely to have access to virtual education (compared to a mother who hasn´t entered the labor market).
- An additional employee at home is associated to a 0.5% increase in the probability of having technical access to virtual education.
- An additional child under 10 years old at home is associated to a 1.8% reduction in the probability of having technical access to virtual education. This effect was reduced during the analyzed period.
- The effect of the number of inhabitants of the conglomerate is almost nil. An increase of 1,000 people leads to a 0.0002% increase in the probability of having technical access to virtual education.

Model evaluation

In this section, indicators are presented in order to prove if the estimated model has a good fit. This is shown in table 10.

Table 10: Evaluation of the Logit Model for students

	2016	2017	2018	2019
Evaluation Measures				
Sensitivity	98,05%	98,70%	98,20%	97,75%
Specificity	13,44%	14,58%	14,19%	17,03%
Positive Predictive Value	86,10%	88,13%	88,63%	87,88%
Negative Predictive Value	55,76%	63,57%	53,68%	55,11%
Rate from false + to true ~ D	86,56%	85,42%	85,81%	82,97%
False rate - for true D	1,95%	1,30%	1,80%	2,25%
False rate + for classified +	13,90%	11,87%	11,37%	12,12%
False rate + for classified -	44,24%	36,43%	46,32%	44,89%
Correctly Classified	**84,97%**	**87,37%**	**87,45%**	**86,47%**
Area under the ROC curve	**0,8000**	**0,8139**	**0,8386**	**0,8350**

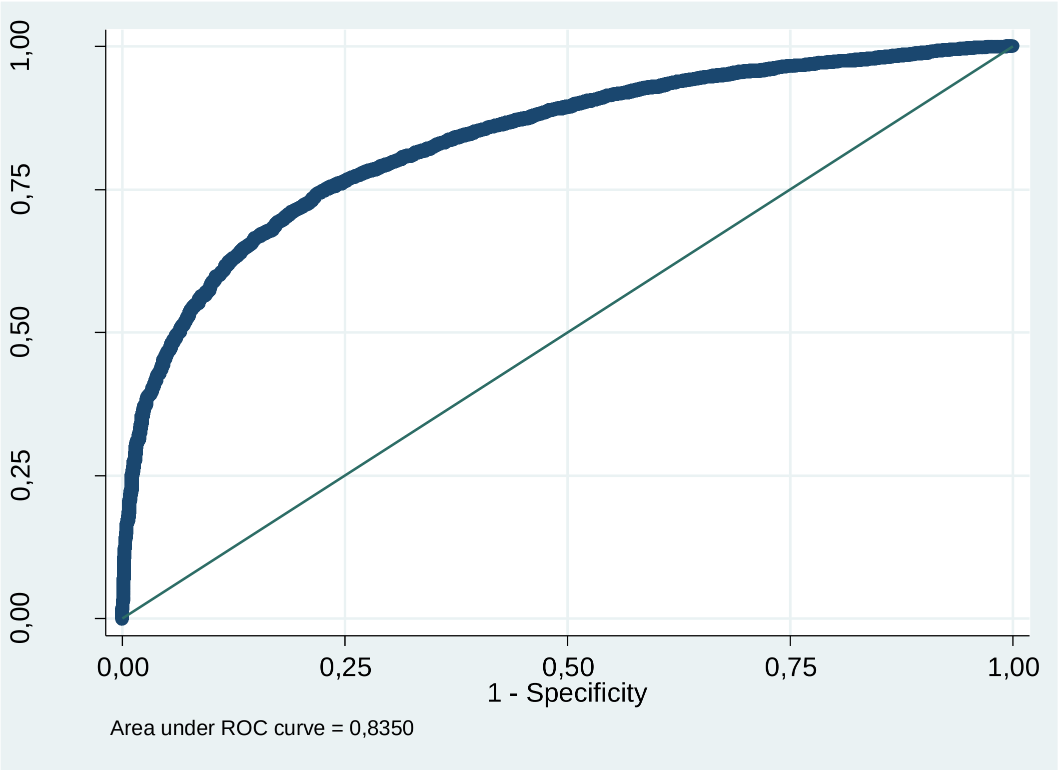
Source: Authors' calculations

Analyzing the data for the year 2019, it can be seen that:

- Every 100 students, the model correctly predicts 86 of them. This percentage of cases which were correctly classified, is good. It fluctuates between 85% and 87.5% depending on the year analyzed.
- The sensitivity of the model of 97.7%. This indicator measures the percentage of students that the model estimates should have technical access to virtual education and that really do. The model is very good at predicting those who have access to virtual education.

- The specificity of the model is 17%. This indicator measures the percentage of students that the model estimates that they should not have access to virtual education and that really don´t. The model is not good at predicting those who do not have access to virtual education.
- The optimal cut-off point between the sensitivity and specificity curves is given for a value of p = 0.85.
- The area under the ROC curve is 0.835, so it is close to 1. This indicates that the model used, in general terms, is quite good. Graph 5 shows the ROC curve.

Graph 5: ROC Curve for students



B.- Case of teachers

Matrix of estimated coefficients

Table 11 shows the estimated coefficients of the variables together with the probability of rejection of the Z statistic (P> z).

Analyzing the data for the year 2019, it can be seen that:

- There are a total of 1,666 teachers participating in the 2019 survey.
- Significant coefficients at 95% are those associated with: teacher's age and years of education, total individual income, people per room and number of inhabitants of the conglomerate. Those related to the teacher's workplace (public), the number of employees within the home and the number of members at home are not significant. We can observe a similar structure for the previous years.
- The coefficient that measures teacher's age effect on technical access to virtual education is negative. In other words, older teachers would be less likely to have

technical access to virtual education which is consistent with the previously expected effect.

- The number of years of teacher education have a positive effect on technical access to virtual education. Teachers with more education would have a greater probability of accessing virtual education. This would be in accordance with the effect expected a priori.
- There is no impact on technical access depending on whether the teacher works in a public or private establishment which would not be in accordance with the effect expected a priori.

Table 11: Logit estimators for teachers

	2016		***2017***		***2018***		***2019***	
Variable	Coef (*p* -value)		Coef (*p* -value)		Coef (*p* -value)		Coef (*p* -value)	
age	-0,0236	(0.00)	-0,0183	(0.00)	-0,0176	(0.01)	-0,0173	(0.00)
educ	0,1865	(0.00)	0,2274	(0.00)	0,2771	(0.00)	0,2767	(0.00)
est_pub	0,0317	(0.82)	0,2411	(0.07)	0,0023	(0.99)	0,2103	(0.14)
iti_m	0,0283	(0.00)	0,0254	(0.00)	0,0273	(0.00)	0,0093	(0.01)
perhab	-0,4100	(0.00)	-0,3108	(0.01)	-0,2607	(0.04)	-0,3632	(0.00)
n_emphog	0,1355	(0.11)	0,0480	(0.56)	0,0243	(0.80)	-0,0729	(0.42)
n_integ_hog	-0,0308	(0.57)	-0,0306	(0.58)	-0,0364	(0.54)	0,0607	(0.30)
n_hab	0,0000	(0.31)	0,0000	(0.75)	0,0000	(0.82)	0,0000	(0.01)
_cons	-0,4682	(0.38)	-1,5009	(0.02)	-2,1051	(0.00)	-1,9214	(0.00)
N	1741		1698		1606		1666	
LR chi2(8)	102,69		103,28		131,74		124,37	
Prob > chi2	0		0		0		0	
Pseudo R2	0,0564		0,0577		0,0814		0,0758	

Source: Authors' calculations

- The ITI coefficient is positive, which implies that teachers with a higher total individual income have a greater probability of technically accessing virtual education which is consistent with expected results.
- The number of people per room (overcrowding proxy) has a negative effect on technical access to virtual education. Overcrowded homes are less likely to have technical accessibility to virtual education. This is compatible with what is expected a priori.
- The number of people in the teacher's household who work has no effect on connectivity.

- The coefficient related to the number of household members has no effect on connectivity.
- The coefficient that measures the impact of the number of inhabitants of the conglomerate is negative. Teachers residing in larger clusters are less likely to have access to virtual education which contradicts what was previously expected.
- The likelihood ratio statistic is high (124.37), so the null hypothesis that all slope coefficients are simultaneously equal to 0 is rejected. Pseudo R2 which measures the goodness fit for the logit model, states that the independent variables are statistically significant at a close level of 7.58%.

Marginal changes

Table 12: Marginal Changes of the Logit for teachers

	2016		***2017***		***2018***		***2019***	
Variable	Efecto marginal (*p* -value)		Efecto marginal (*p* -value)		Efecto marginal (*p* -value)		Efecto marginal (*p* -value)	
age	-0,0037	(0.00)	-0,0029	(0.00)	-0,0026	(0.01)	-0,0025	(0.00)
educ	0,0296	(0.00)	0,0366	(0.00)	0,0408	(0.00)	0,0397	(0.00)
est_pub	0,0050	(0.82)	0,0387	(0.07)	0,0003	(0.99)	0,0302	(0.13)
iti_m	0,0595	(0.00)	0,0656	(0.00)	0,0815	(0.00)	0,0417	(0.01)
perhab	-0,1112	(0.00)	-0,0842	(0.02)	-0,0644	(0.05)	-0,0891	(0.01)
n_emphog	0,0215	(0.11)	0,0077	(0.56)	0,0036	(0.80)	-0,0105	(0.42)
n_integ_hog	-0,0049	(0.57)	-0,0049	(0.58)	-0,0054	(0.54)	0,0087	(0.30)
n_hab	0,0000	(0.31)	0,0000	(0.75)	0,0000	(0.82)	0,0000	(0.01)

Source: Authors' calculations

Analyzing the data for the year 2019, we can see that:

- An extra year of age of a teacher is associated to 0.2% reduction in the probability of having technical access to virtual education.
- Adding one year to every teacher´s education increases the probability of technical access to virtual education by 3.9%. This effect increased during the period analyzed.
- If the teacher works in a public establishment, it has no effect on the probability of access to virtual education.
- If the total individual income of the teacher increases by 1%, the probability of having technical access to virtual education increases by 4.1%. This effect has an inverted U shape during the period analyzed.
- When the number of people per room increases by 1%, the probability of access to virtual education is reduced by 8.9%.

- An additional employee at home has no effect on the probability of having technical access to virtual education.
- An additional member of the household has no effect on the probability of having technical access to virtual education.
- The effect of the number of inhabitants of the conglomerate is almost nil. An increase of 1,000 people leads to a decrease of 0.001% in the probability of having technical access to virtual education.

Model evaluation

Indicators are presented in order to see if the estimated model has a good fit. This is shown in table 13.

Analyzing the data for the year 2019, it can be seen that:

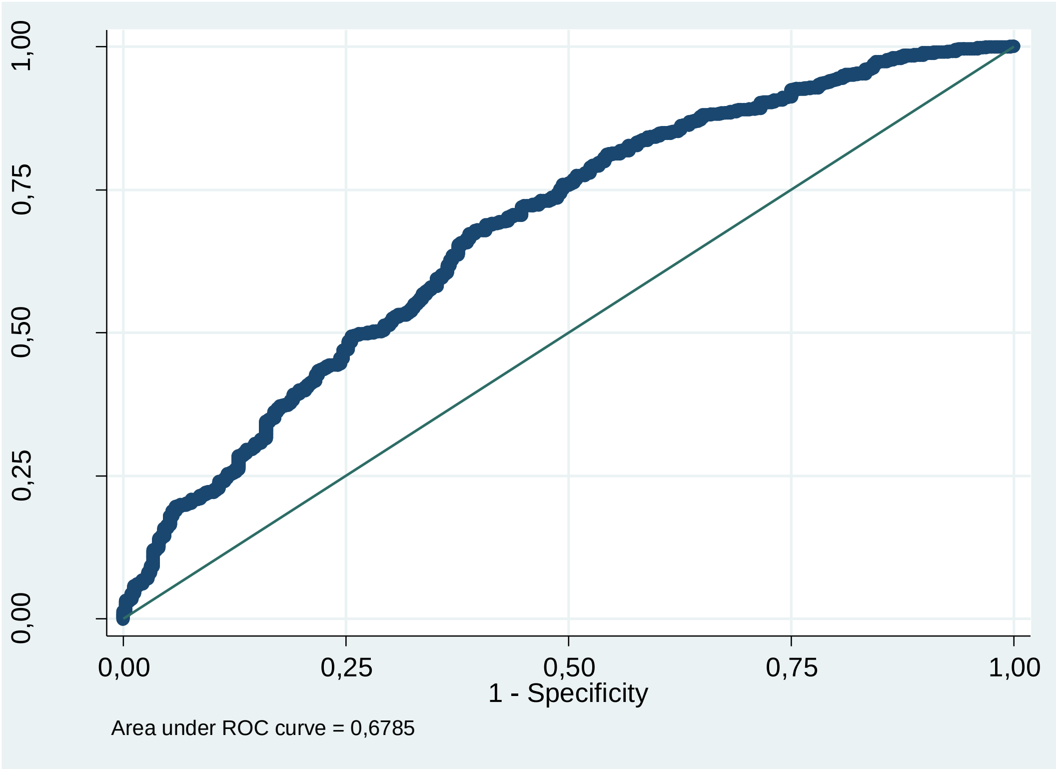
- Out of 100 teachers, the model predicts 81 of them in the correct way. This is a good percentage for these classified cases and it fluctuates between 78.5% and 81.4% depending on the year analyzed.
- The sensitivity of the model equals 99%. This indicator measures the percentage of teachers that the model estimates should have technical access to virtual education and really do. It is very good at predicting teachers who have access to virtual education.
- The specificity of the model is 8.6%. This indicator measures the percentage of teachers that the model estimates should not have access to virtual education and really don´t. It isn´t good at predicting teachers who do not have access to virtual education.
- The optimal cut-off point between the sensitivity and specificity curves is given for a value of p = 0.8.
- The area under the ROC curve is 0.678, so it is close to 0.5. This shows that this model isn´t altogether good. Graph 6 shows the corresponding ROC curve.

Table 13: Evaluation of the Logit Model for teachers

	2016	2017	2018	2019
Evaluation Measures				
Sensitivity	98,75%	99,02%	99,53%	99,03%
Specificity	6,63%	5,88%	9,54%	8,64%
Positive Predictive Value	79,28%	78,83%	81,26%	81,78%
Negative Predictive Value	59,52%	62,86%	83,78%	68,29%
Rate from false + to true ~ D	93,37%	94,12%	90,46%	91,36%
False rate - for true D	1,25%	0,98%	0,47%	0,97%
False rate + for classified +	20,72%	21,17%	18,74%	18,22%
False rate + for classified -	40,48%	37,14%	16,22%	31,71%
Correctly Classified	**78,81%**	**78,50%**	**81,32%**	**81,45%**
Area under the ROC curve	**0,6711**	**0,6624**	**0,6874**	**0,6785**

Source: Authors' calculations

Graph 6: ROC Curve for teachers



6.- Concluding remarks

The emergence of Covid-19 at the end of 2019 forced almost all education systems in the world to change from face-to-face education (slightly complemented by virtual education) to exclusive virtual education. That is to say there was a complete substitution between both teaching methodologies. Argentina was not the exception and various mechanisms and platforms were quickly implemented in all educational systems in order to continue the teaching-learning process.

This article aims to analyze empirically how the different actors of the educational system were technically prepared to face a virtual education process. In addition, it seeks to determine the social - economic variables that are important to explain technical access to virtual education by students and teachers. The analysis is based on EPH data, more precisely on the wave related to the fourth quarter of the years 2016 to 2019.

Specifically, this research seeks to answer the following questions:

How prepared are students to face the virtual learning process from a technical point of view?

85.8% of students in Argentina have the technical skills to participate in the virtual learning process. However, there are significant disparities among regions. While in the NEA (Northeastern of Argentina) 18.3% of the students do not have the proper technical conditions to be able to participate in virtual education, that percentage in Patagonia is only 8.9%.

Inequalities in technical access to virtual education are aggravated when we compare conglomerates. Thus, while in CABA (Autonomous City of Buenos Aires) only 2.9% of students do not have the possibility to participate in virtual education, that percentage rises to 30.6% in San Juan and 37.2% in Santiago del Estero.

In general terms, it can be concluded that the demand for virtual education covers an important area of participation in the virtual learning process, but the differences among regions and clusters are undeniable.

What variables and factors determine technical access to the virtual learning process?

After applying a logit model for all students in the educational system, we can state that technical access to virtual education depends positively on:

The student´s age, the total family income, the educational level of the mother, the fact that the mother is employed in the labor market, the number of people employed at home and the number of inhabitants of the conglomerate (weak effect). Among the variables that negatively affect access to virtual education, the ones that stand out are the following: public school attendance, the number of people per room at home (overcrowding proxy) and the number of people under 10 years of age at the student's house. All the years analyzed maintain the signs.

The main marginal changes of the logit, analyzing 2019, allow us to conclude that:

i) In additional year of student´s age is associated to a 0.9% increase in the probability of having technical access to virtual education. This is a decreasing effect.

ii) if students attend a public school, they are 10% less likely to have access to virtual education;

iii) When total family income increases by 1%, the probability of having technical access to virtual education increases by 5.7%;

iv) If the number of people per room increases by 1%, the probability of access to virtual education is reduced by 9.7%;

v) An additional year of education for the student's mother is associated to a 0.77% increase in the probability of having access to virtual education;

vi) If the student´s mother works in the labor market, then she is 0.9% more likely to have access to virtual education;

vii) An additional employee at home is associated to a 0.5% increase in the probability of having technical access to virtual education;

viii) An additional child under 10 years of age at home is associated to a 1.8% reduction in the probability of having access to virtual education;

ix) The effect of the number of inhabitants of the conglomerate is almost nil. An increase of 1,000 people leads to a 0.0002% increase in the probability of having technical access to virtual education.

Are teachers prepared from a technical point of view to face the virtual teaching process?

76.4% of teachers in Argentina have the optimal technical conditions to be able to participate in the virtual teaching process. However, there are significant disparities among regions. In the AMBA, 26.6% of teachers do not have the optimal technical conditions in order to participate in virtual education, while in the Pampeana region the percentage is 19.1%.

Inequalities are much more powerful when we compare conglomerates. While in Río Cuarto only 3% of teachers do not have the possibility of participating in virtual teaching, that percentage rises to 40.8% in Neuquén.

In general terms, it can be concluded that teachers has important limitations to participate in the virtual teaching process. However, there are special characteristics among regions and conglomerates.

What variables and factors determine technical access to the virtual teaching process?

Applying a logit model for all teachers in the educational system, we find that virtual education has a positive relationship with: the educational level of the teacher and the individual's total income. Those variables that stand out because they have a negative effect on access to virtual education are: teacher's age, the number of people per room (overcrowding proxy) and the number of inhabitants of the conglomerate (slight effect).

The main marginal changes in the logit, analyzing 2019, allow us to conclude that:

An additional year of in the age of teachers is associated to a 0.2% reduction in the probability of having technical access to virtual education;

The increase of an additional year in teacher´s education increases the probability of access to virtual education by 3.9%.

The fact that the teacher works in a public school has no effect on the probability of access to virtual education;

If total individual teacher´s income increases by 1%, the probability of having technical access to virtual education increases by 4.1%;

When the number of people per room increases by 1%, the probability of access to virtual education is reduced by 8.9%;

The effect of the number of inhabitants of the conglomerate is almost nil. An increase of 1,000 people leads to a decrease of 0.001% in the probability of having technical access to virtual education.

Appendix 1: impulse responses

The Technical Index of Virtual Education arises from the questions of the Module of Access and Use of Information Technologies of the EPH. The relevant variables and questions to consider in the aforementioned module are the following:

1. Possession of a pc: In this household: do you have a computer / s?

2. Internet possession: In this household: do you have internet access?

3. Internet use: In the last few months, did you use the Internet?

4. PC use: In the last three months, excluding internet use, did you use a computer?

5. Cell phone use: In the last three months, did you use a mobile phone (cell phone)?

The above questions have 3 response categories: yes, no and don't know / no answer. 99.94% of the answers and more focus on yes and no. Given this, we assume that each question has only two answers: yes (1) and no (0).

By having 5 questions and 2 possible answers, we have a combinatorial of 32 possibilities (25). Table 14 shows all the possible situations and the ITEVI assigned to each one, both for the students (ITEVIa) and for the teachers (ITEVId). It should be remembered that 1 represents "yes" and 0 represents "no".

It can be seen that, of the 32 possible combinations, a total of 21 have ITEVIa = 1 as a result, which implies that the students who fall into these classifications have the technical conditions to be able to participate in virtual education. While the remaining 11 cases, result in an ITEVIa = 0, that is, they are students who do not have the technical conditions to be able to carry out virtual education.

The students who have an ITEVIa = 1 are the following:

They have internet and they have a pc.

They have internet and use a PC or cell phone.

They do not have internet at home, but they use the internet individually either on PC or cell phone (use).

The students who have an ITEVIa = 0 are the following:

They have internet and they don't have a PC and they don't use a PC or cell phone (Netflix).

They do not have, nor do they use the internet.

Of the 32 possible combinations, only in 2 cases do we have an ITEVId = 1, that is, they are teachers who have the necessary technical conditions to be able to participate in virtual education. While the remaining 30 variants have an ITEVId = 0.

Teachers who have an ITEVId = 1 are those who have possession and use of the internet as well as a computer.

Appendix-Table 1. Construction of the ITEVI from the basic questions

Internet tenure	PC tenure	Internet use	PC use	Cell phone use	ITEVIa	ITEVId
1	1	1	1	1	1	1
1	1	1	1	0	1	1
1	1	1	0	1	1	0
1	1	1	0	0	1	0
1	1	0	1	1	1	0
1	1	0	1	0	1	0
1	1	0	0	1	1	0
1	1	0	0	0	1	0
1	0	1	1	1	1	0
1	0	1	1	0	1	0
1	0	1	0	1	1	0
1	0	1	0	0	0	0
1	0	0	1	1	1	0
1	0	0	1	0	1	0
1	0	0	0	1	1	0
1	0	0	0	0	0	0
0	1	1	1	1	1	0
0	1	1	1	0	1	0
0	1	1	0	1	1	0
0	1	1	0	0	1	0
0	1	0	1	1	0	0
0	1	0	1	0	0	0
0	1	0	0	1	0	0
0	1	0	0	0	0	0
0	0	1	1	1	1	0
0	0	1	1	0	1	0
0	0	1	0	1	1	0
0	0	1	0	0	0	0
0	0	0	1	1	0	0
0	0	0	1	0	0	0
0	0	0	0	1	0	0
0	0	0	0	0	0	0

Source: Authors' calculations

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