



LUND UNIVERSITY

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## THE STARRING ROLE OF EDUCATION TECHNOLOGIES IN COLOMBIA

by

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According to the UNESCO, the COVID-19 outbreak has forced millions of students to take virtual classes. For that reason, more than 80% of Higher Education institutions expect a big disruption in the sector in the next five years and 60% of them in the next 24 months (Holon IQ,2020). In Colombia, the big disruption is much needed. Currently, Physical Higher Education holds the lead regarding the performance of its students measured in the results of the Saber Pro test of 2018. However, this performance is strongly connected to the socio-economic conditions of the students. On the other hand, the students that take Virtual Education programs perform in average 10% worse than students from Physical Educational Institutions. This study provides insights, using an OLS regression, about the socio-economic conditions that are affecting the learning outcomes of students from Physical, Virtual, and Blended Higher Education Institutions in Colombia. It demonstrates the responsibility that education technology has in the country to expand the good quality education of physical educations to more students and to improve the quality of education of virtual institutions. In addition, it opens the discussion to use a transition framework to understand the way in which this big disruption could take place.

Keywords: education technology, Higher Education, socio-economic conditions, transition.

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# 1 Introduction

Due to the COVID-19 outbreak, multiple schools have closed around the world. According to UNESCO, it has impacted over 90% of the world's student population and left more than 1.3 billion students out of school. Work and education have been challenged to go virtual as never seen before. From the student's perspective, they are complaining about the high price of the tuition fees of colleges. As reported by the largest financial newspaper of Colombia, more than 10.000 USD per year for having classes turned into Zoom meetings seems a fraud for many students (Portafolio, 2020). Even though digital education has been going on for many years, it still has not found itself to be more important than to go to a school room and listen to a teacher live. The circumstances for Educational Institutions have changed and probably after the pandemic is over, virtual education might have a larger share of the teaching space or might have a rebound effect in which people realized the importance of being physically present in a classroom.

Colombia is among the countries where students opt for private institutions with more than 60% of the undergraduates enrolled in them (Saber Pro Database). As stated by the World Bank (2005), private institutions are the most efficient element in the education sector of developing countries. They are the ones who can respond fast and efficiently when facing sudden market changes. However, their quality varies considerably between them. In the best ones, all of them on the physical education category, students without a proper primary and secondary school preparation are less likely to enter.

Blended and virtual programs are usually more affordable due to the higher number of students per teacher than physical traditional ones. Yet, their quality is not recognized in the labor markets nor quality education rankings. Students that could not afford to enter to the top universities have the option to prepare to undergo a difficult exam to get one of the spots in a physical public institution of good quality like La Universidad Nacional de Colombia. The spots are limited because the budget for public education is also limited. The problem is that the preparation for the exam is also costly and it implies the movement of the students to the cities where these top-quality public institutions have their facilities. Consequently, the best public and private institutions are crowded of medium, medium-high, and high-income students that can afford it.

Nowadays, digitalization represents an opportunity to cope with the increasing population of developing economies that traditionally would have been excluded from the good education. As the Education Market Intelligence platform Holon IQ mentions, the LATAM Education Technology ecosystem is a key social and economic driver. Furthermore, the challenge for Educational Institutions goes further than to implement new technologies, they also need to update their academic offers. Latin America has the biggest skills gap in the world (Flores & Melguizo, 2018). According to ManPowerGroup surveys from Flores & Melguizo (2018), 59 % of companies in Argentina and 50% of companies in Colombia struggle to find talent with the right skills.

Private and Public Higher Education Institutions are struggling to fulfill the expectations of students who have discovered the financial success of finding the right knowledge and skills on the internet. For a constantly increasing population, studying in a university, if it is not a world top one, is not worth it for them. As an example, Universidad del Quindío and Universidad Cooperativa de Colombia, both Higher Education Institutions, have expressed their concerns regarding dropouts from college. In the past two years, according to the system to prevent and analyze the student's dropouts (SPADIES), the rate of dropouts has increased 20% and with the COVID-19 it does not seem to get any better. The reasons behind it might be failure to keep an updated content, teaching methodologies and tuition fees.

Therefore, the higher education system in Colombia, and around the world, needs to change directions. The current system is not financially, nor operationally, sustainable for students. The answer might be a blended higher education that provides both digital and physical experiences. One does not exclude the other. However, it is important to know what level of importance each of them could have in the future of the students. In addition, young students have more access to knowledge from everywhere in the world. The rapid way in which they can learn, and the need for an early income, means they are not willing to wait a long time to obtain a degree. The challenge is complex but not impossible.

This study contributes with knowledge about the influence of the socio-economic conditions of the students on their learning outcomes. Under the current situation of the Higher Education Institutions in Colombia there is a need to show empirically the inequality of knowledge in the country. The implication of the present thesis is to open the discussion about the big role of educational technology on narrowing the economic inequality in the country by supporting the access for more students to a better-quality Higher Education.

## 1.1 Thesis Aim

This thesis aims to know what are the socio-economic factors that are affecting the performance on higher education in Colombia. Then, we want to investigate the importance of virtual education on serving as the vehicle that decrease the inequality of knowledge in the country and boost its economic and social development. The goal is to offer useful knowledge and material for entrepreneurs, administrative directors, decision makers and policy makers of the education sector. Therefore, we propose the following research question:

***To what extent does the type of education (physical, virtual, or blended) affect the students' learning outcome?***

In Colombia, multiple virtual education programs have been available for students for more than 25 years. They operate in a space with constant adoption of technologies and evolution of their regulatory framework. We develop a model that compares the results of the Saber Pro test of virtual, blended, and face-to-face higher students from higher education institutions. The test is mandatory for every student that wishes to obtain a legal diploma approved by the ministry of education.

By comparing statistically the results, we will be able to know to what extent taking virtual education instead of face-to-face education affected the results of the Saber Pro by the end of 2018. Also, this study provides information about the socio-economic conditions under which

learning is effective. Therefore, decision makers in educational institutions could review their current education system and check for improvements opportunities. Then, policymakers and practitioners will know about the effectiveness of Internet based interactive online learning approaches before the COVID-19. If decisions are taken, they can evaluate a before and afterwards of the socio-technical higher education system in Colombia.

Furthermore, the transition framework of Geels & Schott (2007) offers the chance to see the way in which virtual education is taking over traditional education. Their explanatory approach to our knowledge has not been used in the education sector and it remains powerful to explain changes in systems in critical times.

## 1.2 Scope

The present thesis will focus on Colombia. A country with different Edtech startups, top universities and a rapid economic development taking place. Colombia works as a proxy to understand the role of virtual education technologies because most countries in LATAM have the same language, culture, and perception of education.

The research will allow us to understand the socio-economic drivers of the three types of higher education in Colombia. However, it will not tell us inside those types, what are the methodologies, techniques, know-how, technologies, and operations that are effective for them.

The research will provide the conditions in which virtual education is going to take off and the challenges it faces regarding the socio-economic conditions of its students. Furthermore, it will provide the big picture in which the education technology can enter the higher education socio-technical system using the transition framework of Geels & Schott (2007). Still, it does not compare two periods in time to analyze fully the transition.

## 1.3 Outline of the Thesis

The research will start Section 2 with a literature review on the socio-economic conditions that affect student's performance and the relevance of virtual education. Then, we will move to Section 3 in which we make a contextualization of the situation of virtual education in Colombia. Afterwards, in Section 4 we will present the data and we will describe the socio-economic conditions of every of the types of education. Section 5 presents the quantitative model to explain to what extent these socio-economic conditions affect the results of the learning outcomes of the students. We could see that physical education holds the best results, but it is a type of education in which the socio-economic background of the student matters. For virtual education, the results are slightly lower, and the socio-economic factors were not as relevant as for blended and physical education. Therefore, in Section 6, we discuss the role of the education technologies, through the transition framework of Geels & Schott (2007), to promote a democratization of knowledge and the policy implications of the study. Section 7 presents the conclusions and the recommendations for further research.



## 2 Literature Review

This section provides a literature review of the expected socio-economic variables that affect learning outcomes and the effectiveness of virtual education in the global context.

### 2.1 Socioeconomic Conditions and Methodology

The conditions in which students' live matter for their education. Azzizah (2015) studied the socio-economic conditions that made Western and Eastern Indonesia obtain different study outcomes. They were only concerned with student enrollment and studied its relationship with poverty rate, the Gini Index and the gross domestic product of the region. Poverty rate was the biggest influencer in a low student enrollment of the West. In the same line of research, Kumar (2018) recommended that for studies analyzing students' performance the parental income, the gender, the parent's education level, the social background and the class attendance were crucial variables. Rahman & Uddin (2009) also confirmed the importance of father's literacy and income. In general, there is no doubt that socio-economic conditions will affect the student's performance, the question is still to what extent in Colombia?

Furthermore, the present research wants to connect socioeconomic conditions with education technologies. Previous studies tried to overcome the negative effects of socioeconomic conditions with a growing mindset of the students. Claro et al. (2016) connected two structural factors that affected academic achievement: psychological factors, i.e. student's belief about their abilities and socioeconomic background. They concluded by checking the significance of the variables related to those factors that having a student growth-mindset was as influential as coming from a high socioeconomic condition.

The quest to address the negative influence of socioeconomic status is enduring and of global significance (Mowat, 2018). The all world suffers from this problem and it has no direct solution nor direct responsible. Economic inequality is on the rise. Therefore, its consequence on the educational outcomes is inevitable if nothing is done. Even though the problem is global, and every region must tackle it with a holistic approach, the first step to overcome it in Colombia must be to study what specific factors are relevant for the learning outcomes.

To do that, we will use a similar approach as Melguizo & Jacques (2016). They used the National Student Performance Exam (ENADE) from Brazil to analyze the learning outcomes of the students. In our case, it is an advantage to have the data of a college-compulsory examination, i.e. Saber Pro Test, that allows to measure knowledge gains and the socioeconomic conditions associated with the individual.

The methodologies to study the data can vary but most of them look for correlations, significant variables, and the size of their effect. For example, Ko (2016) used a structural equation modelling to examine the structural relationships between student's learning outcomes and

factors that related to those outcomes. In his case, it was college environment, class participation, student-faculty interaction, and integration experiences. On the other hand, Claro et al. (2016) used canonical correlation coefficients to test for the existence of differences in the learning outcomes according to the mindset and socioeconomic background of the student.

## 2.2 Virtual Education

Virtual Education has been praised for having online students that tend to be self-motivated, self-disciplined, and self-directed, which makes Virtual Education a very popular modality nowadays (Grisales et al., 2020). On the other hand, Virtual Education also challenges the teachers. They must find ways of adapting presential teaching strategies to the virtual world, learn how to use the technologies that are available for creating content and deal with the low retention rates. Some studies like Yang et al. (2013) focused on how these Massive Open Online Courses, i.e. the technology itself, can retain and engage with the students.

In 2009, the US Department of Education conducted a meta-analysis research about the learning outcomes of online education versus face-to-face education in undergraduates, medical and military training (Means et al., 2009). They reviewed 51 studies and found that students who took all or part of their class online performed better, on average, than those taking the same course through traditional face-to-face instruction. Also, that blended education scored better than the face-to-face and the total online learning way. Among other findings are students that spend more time doing a task in online learning than in a face-to-face environment, performed better and that the effectiveness of online learning approaches appears quite broad across different content and learner types. The study also concluded that providing guidance for learning for groups of students appears less successful than does using such mechanisms with individual learners and that online learning can be enhanced by giving learners control of their interactions with the media and prompting learner reflection.

Later, another study found something different in the K12 education in the US. Molnar et al. (2019) conducted research about virtual schools in the US. They discussed with data two popular ideas about virtual education: students get customized education and therefore, they learn more and, costs are lower for virtual schools therefore it is highly appealing for for-profit organizations and policy makers to get more involved. They considered mostly K12 groups and their recommendations for policy makers are clear: stop the growth of virtual schooling until enough research has been done. The reason behind is that according to the report the students are performing worse in blended and virtual education compared with presential education. They think policy makers should slow or stop the growth of virtual education until the poor performance causes have been identified and addressed.

In addition, Molnar et al. (2019) recommended policy makers to enforce sanctions on virtual and blended schools that perform inadequately and sponsor research about virtual education. The vision of the authors touched upon the governance of virtual education. They want policy makers to make sure that the curriculums are good enough, that virtual schools do not prioritize profit over student performance and implement measures that require virtual and blended schools to reduce their student-to-teacher ratios. Even all of them are valid recommendations, considering the non-stopping natural growth of online education with millions of students around the world having access to it, they do not seem applicable in real life scenarios.

Virtual Education is bigger in China than in the US. The research done for the K12 virtual schools advice to not slow down the growth of them, but to prepare better the teachers to adapt to the technology (Chen et al.,2009). They pointed out that the technology and the methodologies go through a normal process of maturity in which learners and teachers will improve their performance. China is without any doubt leading the way in terms of innovation in education.

An OECD article by Stéphan Vincent-Lancrin written on the 14 of April of 2020, in the middle of the coronavirus global struggle, reviewed the motivation coming from governments to speed up or to slow down the growth of the Edtech sector. Due to the lack of official sources from governments that follow the investments in innovation for education, digital education technology and education venture capital, researchers must come to private companies like Holon IQ whose job is to gather and exploit this data. The author wonders about whether there are enough private actors and enough capital investment to develop the tools and resources that should help improve education globally.

Vicent-Lancrin (2020) finds that China invested USD 600 million in 2014 and went up to 5.2 billion in 2018, which means that nowadays over 50% of all global venture capital in education now comes from China. To be more precise, in 2018, 63% of the total venture capital for technology in education was invested in China compared with 20% by the US, 9% by India and 6% by the European Union. The benefits from those investments are already noticeable too: 7 of the top 10 education unicorns, and 9 out of the 30 largest listed global education companies were Chinese in 2019. This also means that there is a chance that only a handful of global education technology actors dominate the world. It could be risky for the biases towards content, methodologies, and lack of regulation (Zeide & Nissenbaum, 2018).

As China is the leading in investment, it is worth noticing what different scholars have found about its rapid digitalization of its higher education system. Zhao & Zhang (2006) found out at the time that the government struggled to strike a balance between tight regulation and flexibility, between tradition and innovation, and partly reveal the current social, political, economic, and educational realities in China with regard to online education.

Companies like Blackboard and Moodle took over the world as the globally successful Learning Management Systems. Nowadays, investments are augmented/virtual reality solutions, then robotics, then artificial intelligence and blockchain. All these technologies are linked to the internet, and therefore available in any country. Still, the OECD office for education and skills have been worried about the lack of motivation for virtual education from students. Vicent-Lancrin (2020) critiques come from the disappointment in virtual education of today in the middle of a crisis. If more investment, and more research would have taken place, the coronavirus education situation could have been more than Zoom calls.

Gonzales et al. (2017) were curious about the perception of low student motivation behind virtual education. They proposed a constructivist and gamified methodology to tackle the problem. They based their research on the work of Huertas J. (2006) who said that student motivation comes from: feeling proud/ashamed of the results, take control or influence another individual and establish affective relationships with other individuals. Nowadays, not like presential education but in a virtual experience, people can share their achievements on LinkedIn, influence other people thanks to their number of followers and create affective online relationships that could turn into presential ones.

About the adoption of virtual education, Van Raaij & Schepers (2008) used the Technology Adoption Model to describe a sample group of Chinese MBA student's engagement, and motivation, in the technology. The model deals with human behavior related to different personality traits. The hypothesis of the model are how that the perceived the usefulness of the system, i.e. virtual education, will have a positive impact on system usage, the perceived ease of use of the system will have a positive impact on perceived usefulness of the system and that the perceived ease of use of the system will have a positive impact on system usage . In addition, they include the personal innovativeness in the domain of information technology, computer anxiety and the influence of subjective norms. The results of their study supported those variables for adoption of Edtech. Also, they remain relevant to understand that Western or Asian educational institutions, and venture capital firms, who wish to internationalize their programs and use their home-grown e-learning systems to support programs abroad are dealing with a standard behavior of students. In other words, education technology deals with a similar type of student in any part of the world which makes it easier for the adoption and spread of new technologies and methodologies.

Zeide & Nissenbaum (2018) went further to discuss the role and the rules for Massive Open Online Courses. When education turns into a marketplace, the providers undermine the core values of education and its support for economic growth. The authors mentioned the importance of education for promoting democracy, equal access opportunity and self-actualization. However, current physical education spaces seem to not follow any of these. When authors write about virtual education, they seem to compare it with a perfect education system that provides access to everyone to a high-quality education. That is not the case for Colombia and the US, countries where education is a business that is clearly for-profit and with a hard accessibility for the masses. However, Zeide & Nissenbaum (2018) work goes beyond being concerned with the data privacy and regulations that are not applying for virtual education. Their concern about virtual education lays down that if not ethical and lawful governed, virtual education can encourage narrow viewpoints and reduce learning to a purely instrumental exercise focused on economic outputs and quantifiable outcomes.

## 3 Contextualization

In this section, we provide background information about the current state of Higher Education Institutions, the challenges of virtual education and its situation in Colombia.

### 3.1 Higher Education

According to Holon IQ, one of the largest market intelligence platforms for education in the world, Higher education, compared with K12, workforce and pre-K, has the highest global market cap from various stock exchanges and it has gained most attention from startups and investors in the US and the world since the world economic crisis of 2008. The education market is highly competitive and conservative as only 2,5% of total investments in education went to Education Technology in 2018 (Holon IQ, 2020). Technology providers deal with long sales cycles. Budgets from Higher Education usually go to pay expensive teachers and to maintain the physical and digital infrastructure but rarely to invest in new technologies. Furthermore, as presented by the Global Education Outlook Survey, almost 60% of Higher education institutions expect a big disruption in the sector in the next 24 months and above 80% of Higher Education is expecting a big disruption in the sector before 2025 (Holon IQ, 2020). A sign of this is that by March 2020 expenditure in new technologies went up to 24% (Holon IQ, 2020).

Higher education is expensive in countries like the United States or Colombia. It is financed by the government in countries like Sweden, Germany, and many others. However, the spots are still limited. Not everyone has access to it. Many people are being left out around the world because there is not infinite physical capacity in universities to deal with the increasing number of students. It means that an increasing share of the population that has the capability to add value to the economy are not doing it. Therefore, there is a need and an opportunity for technologies that can fill the gap.

Students now have more options with the revolution that came with the Massive Online Open Courses platforms like Coursera, Udacity and Udegy. People can choose to take an online bachelor's degree or an online master's degree from home. Coursera offers courses from the highest ranked universities in the world like Harvard or MIT. Accessibility to education then seems to be solved thanks to these platforms that keep growing.

With more options, other problems have arisen. The completion rate is low for the courses they offer. For Coursera, a MOOC that raised USD 103 Million in 2019, it is around 10% (Baek & Shore, 2016). Engaging is hard in virtual education when people are not forced to do it or when people just do not go physically to the place, have friends in the classroom and just experience education life. Nevertheless, completion rates in physical universities are also not high. In Colombia and in the United States, the benchmark for dropouts in Higher Education is around

40% and it is highly related to the financial needs that students face when studying as it was exposed by David Kirp on his book “The College Dropout Scandal”.

Higher Education ranks as a safe investment in most countries around the world. People do it because it will bring economic prosperity and a life. Governments support it because it boosts economic growth. Physical and Virtual education both have their problems, advantages, and disadvantages. Both are failing to engage, maintain and fulfill the expectations of students while facing financial challenges. These problems also occur at a totally different level because Coursera is dealing with a user base of more than 40 million students worldwide while a university hardly has more than 20.000 active students (Class Central MOOC Report, 2018).

In addition, the operational challenges that traditional education face are increasing. The so-called “market for skills” is considered more important than the market of traditional degrees. Five years long programs are becoming four years programs. And, those which are four years are becoming three years programs. Innovative institutions are realizing the importance of certifying not only a full body of knowledge in a field but also special competencies. The soft skills like public speaking or ability to work under pressure are being more demanded than the knowledge itself by the employees.

## 3.2 Virtual Education in Colombia

Virtual Education represents a life changing opportunity for people that usually do not have the schedule that fits into a normal study plan, the financial resources to pay for it and the transport to go to presential classes. The main goal for virtual education in Colombia is to reduce the inequality, which is double than the average for its peers at the OECD, that came with the rapid economic development that occurred in the country in the beginning of the new century. According to the report of Radinger et al. (2018) for the OECD, Colombia is currently facing a fiscal lack of resources for education, integration between different educational institutions that allows knowledge spillovers and the need to promote a new vision of the professionalism of teachers that allows a more efficient and equal assignation of them.

Regarding virtual education, the government has not done a good job with the platform “Colombia Aprende”. Still, the resources do not go to the rural areas as they should be. In the past, Escuela Nueva was a successful teaching methodology, for group learning and problem solving for the rural areas, which gained international recognition, but since then, there have not been innovations with such impact. When teaching online, the quality of the content is not the best because they are trying to copy the same methodologies of the physical world to the virtual one. They lack the interaction that must take place between the content and the student and, the teacher and the students.

In Colombia, virtual education started around 1998 with Universidad Militar Nueva Granada launching virtual content and Fundación Católica del Norte which was created with the purpose of being a 100% virtual private higher education institution (Yong et al., 2017). From that date, other universities started to provide specializations and partnerships with foreign universities to promote ICT in their institutions.

The main goal of these types of institutions is to reach the population that does not have the financial resources to pay for a full presential program. It challenged the content and the

teaching methodologies of traditional education. According to the SNIES (Information System for Higher Education Data), from the year 2016 to the year 2018, there was a fall in the population accepted for higher education programs from 1.180.000 to 1.101.000. In total, around 5% of the academic offer in Colombia was virtual education. Also, by 2016 only 2 virtual out of 841 undergraduate presential programs were accredited by the Ministry of Education.

In Colombia, by 2016 there was only one master program focused on management of virtual education (Yong et al., 2017). Therefore, now there is a clear need for more education for professionals that want to join the digital transformation of education. The lack of qualified talent that can lead technological change may be a factor that has slowed down the process of providing more content and better-quality virtual education.

Virtual universities in Colombia are aware that if they upload good content and at a fair price, they will get international students involved. However, they fail to reach international and national standards of quality education due to the complex circumstances in which they operate (Carmona & Rodríguez, 2017). Furthermore, the will of digital transformation seems to come, more strongly, from the universities that are already not offering a top-quality education.

In 2010, the Ministry of Education released a report exposing the guidance for virtual education in Colombia. The Colombian government has been aware that Virtual education can be also called incorporation of the ICT in Education. According to Sangrá & Gonzales (2004) its incorporation goes through a process of getting the technology, teaching the teachers how to use the technology, learn and develop methodologies to teach using the technologies and lastly the incorporation goes through an evaluative process in which good practices are selected. At the end of these four phases, the ICT incorporated can show its benefits or its failures.

In the 2010 plan of the Colombian government, virtual education is assumed to be guided through a constructive perspective. Teaching is not a process of passing information to the student, but it must focus on building the necessary competences to the student to build and rebuild knowledge according to the circumstances. Therefore, the guidelines of the government for virtual education have four dimensions: pedagogical, technological, communicative, and organizational. Higher Education institutions must follow the guidelines to qualify as virtual education provider by the government:

- In the pedagogical dimension virtual education must be conceived as part of the core objectives of the institutions. Among other aspects the government requires that passing from a presential to a virtual mode require adjustments in the teaching methodologies, that the courses could be given asynchronous or synchronous and that the autonomy of the student must reflect its freedom to take decisions and be responsible.
- The communicative dimension allows the pedagogical dimension to be successful. Students and teachers must be able to communicate effectively and efficiently. Among the guidelines the government exposes the need to promote the interaction between the student and the teacher, to use the right ICT tools at the right moment, to exploit the variety of ICT tools and to protect the rights of the authors. The government expects that response time to any inquiries by the students will not be attended in more than 24 hours and that virtual communities will allow knowledge spillovers nationally and internationally.
- In the technological dimension, the government makes sure the higher education institutions make sure they have the right software, hardware, and connectivity. They must plan strategically the allocation of resources, the cybersecurity of their ICT

solutions and the integration of all tools used to allow the unification of teachers, students, and administrators.

- In the organizational dimension, the institution must understand the deep implications of providing virtual education. Virtual education must incorporate the vision and strategy of the institution and it must have clear “rules of the game” for the actors involved. In addition, institutions must be careful with their investments in ICT for virtual education, they must have people especially working for it and at the same time making sure that when designing a new course all actors are involved in the process (a teacher, a web designer, a web master and a pedagogic master, etc.)



## 4 Data and Method

In this section we present the data, its descriptive statistics, and the methodology behind the analysis.

### 4.1 Data

In Colombia, every student must take the SABER PRO test before they finish university to obtain his degree. This test is created by the Instituto Colombiano de Evaluación de la Educación (ICFES) and its aim is to provide insights about the competences of the students that are about to graduate and also, it allows the comparison between different institutions and programs, and, it also work for the state and universities to formulate new policies to improve the quality and efficacy of the higher education system. Both virtual and physical education students must take the test.

The test has its failures and critiques. Students do not put much effort into getting the best results as it is only a requisite to graduate. It is believed that the test is also not useful for getting a job. None hiring is asking for a certain level of results. However, it works well to show the differences between virtual and physical education in the country. It will allow us to draw conclusions about the current state of higher education in Colombia. The goal with the data is to prove if there is any statistical difference in the results of the tests of students with a virtual education than with a physical one.

The [dataset](#) to be used are the results of the SABER PRO test in the second semester of 2018. It consists of 237112 results of students. Out of those, 9845 are virtual education programs and 39884 are programs taken in the distance. The distance programs are not 100% virtual as they require some presential classes. Therefore, they work as a proxy for blended education.

To avoid selection problems in the sample, and to run the model smoothly, we do two things. Using random excel numbers we choose 5000 presential, 5000 blended and 5000 virtual programs. We use the formula of Excel that generates a random number and then, I filtered the dataset from lower to high according to the random number. We pick the first 5000 observations of each list. Then, for all the variables with string values, we replace them with numbers, and we take out the missing values.

### 4.2 Descriptive Statistics

We illustrate the relationship of each variable with the type of education and with the Global Score of the test. The goal of this to provide descriptive statistics to understand what the

population under study look like. We look at the preferences and scores of the students according to their socioeconomic characteristics. There is an inequality of the quality of education that one may be able to receive depending on any of these variables. Also, we will explore clear differences on the type of education chosen according to the struggles and conditions in life of each of the students.

### Type of Education

Our variable of study is the Type of Education. It can be virtual, blended, or physical. In blended education the student must go physically to the institution at least one time during the semester. Physical education means that all the classes are in classrooms and the student must assist at least to 80% of them during his/her studies. Virtual classes are classes taken from anywhere using a computer and a virtual class software. The description of the Score averages, according to the Type of Education, can be found in Figure 1.

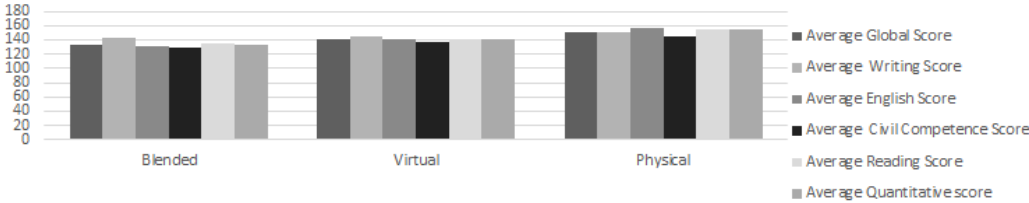


Figure 1. Average Score of the Saber Pro according to the type of education.

### Gender

For gender, we can see on Figure 1, that on average men are performing better than women in all categories but writing. However, the number of females is slightly higher than the total number of males graduating during 2018.

Due to the sample, we have significantly more women than men which reflects the reality of education in Colombia, i.e. more women are getting educated than men. In the complete dataset, women accounted for more than 62% of the observations, and men 38%. Regarding the type of education, in Figure 3, women surprisingly tend to opt for blended education while men tend to opt for physical education.

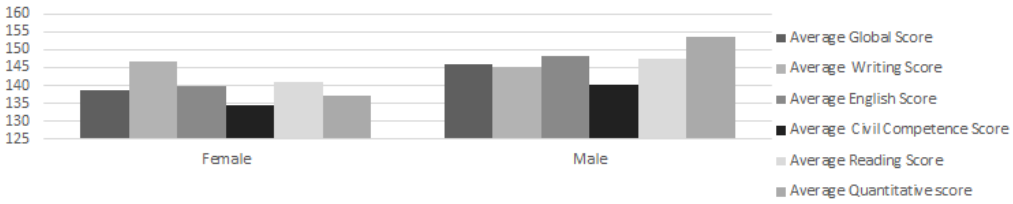


Figure 2. Scores according to gender.

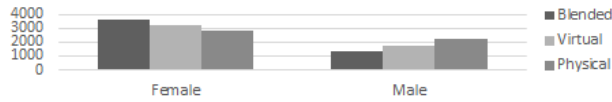


Figure 3. Type of education according to the gender.

## Study Abroad

Studying abroad, according to Figure 4, influences the score of the student in every module. Gaining international experience opens the mind of students, improves their english and makes them score better in the Saber Pro test. Of the people that decided to not study abroad, most of them decided to take blended education. This characteristic is correlated to the fact that the sample is composed mostly of women and they hold a preference for blended education. On the other hand, only 93 of the people of our sample studied abroad and their preference was virtual education according to Figure 6.

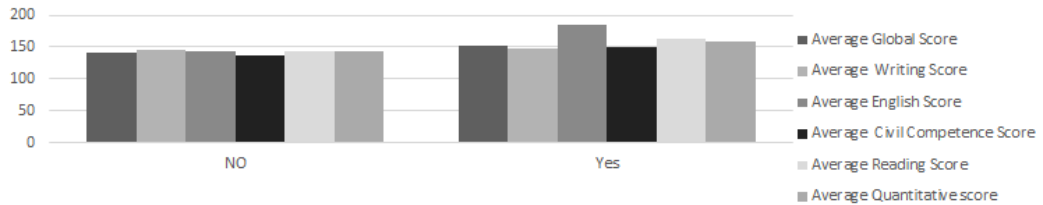


Figure 4. Average Score of the students according to the fact if they have studied abroad or not.

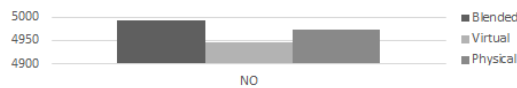


Figure 5. Type of education according to people that did not study abroad.

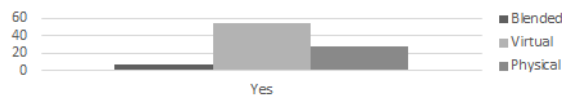


Figure 6. Type of education according to people that did not study abroad.

## Minor Group Ethnicity

In an ethnic divided country as Colombia is, the race of the students keeps playing an important role in education. Indigenous people and other minor group ethnicities do not find fit in the modern economy according to Figure 7. Therefore, their results are significantly lower than the

rest of the population. In total, 7% of the students from the sample are from a minor group ethnicity.

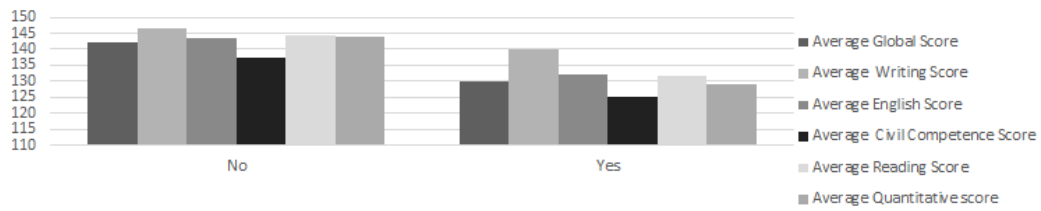


Figure 7. Average Score according to the ethnicity of the student.

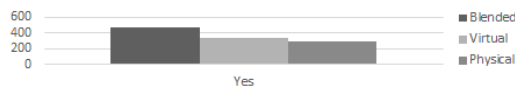


Figure 8. Type of education for students with ethnicity.

### Type of location

Usually rural areas score lower in the Saber Pro test. The highly concentrated economic development of cities has not touched fully the rural areas. The country suffers from economic inequality and the education results show it.

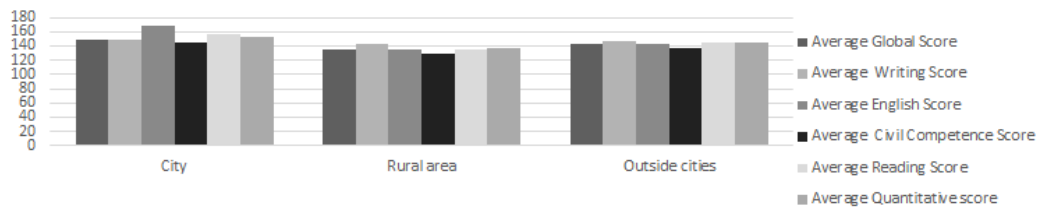


Figure 9. Average Scored according to the location of the house.

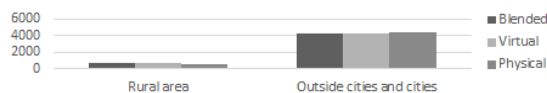


Figure 10. Type of education according to the ethnicity of the student.

### Tuition Fee of Institution

Inequality causes that offer of good quality education be limited. The resources are limited, therefore the price increases. Those who can pay for good quality education tend to score better in the Saber Pro. Tuition fees, as mostly everywhere in the world, have increased more than the

inflation per year. The gap regarding quality education between middle income and low-income students in the country keeps growing.

Regarding tuition fees associated with the different types of education, there were no physical programs for less than 2,5MM COP. Also, in Figure 12, we can see that most programs range between 1MM COP to 2,5 MM COP, and that they are mostly virtual programs.

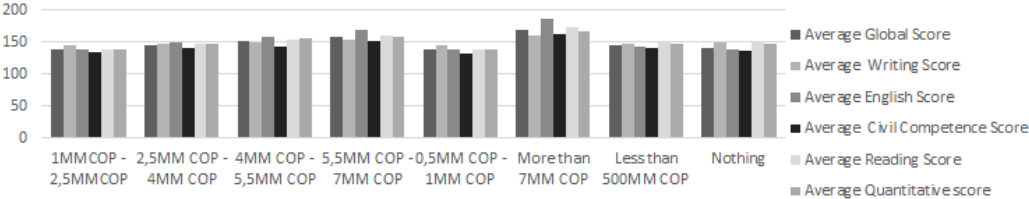


Figure 11. Average Score according to the cost of the tuition fee of the Institution.

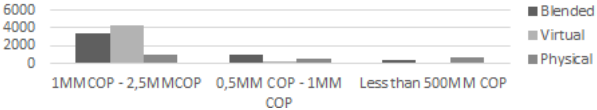


Figure 12. Type of education according to the tuition fee of the Institution.

### Stratum of the Student

In Colombia, the stratum <sup>1</sup>of the household is correlated with the income, health and in this case, quality of education. Living expenses are significantly higher compared between two levels of Stratums, i.e. in Stratum 6 compared with Stratum 4, and so on. The stratum will dictate what type of education the student will have. Stratum 6 has the best English results, however, being from that status does not guarantee to have the best civil competences.

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<sup>1</sup> The Stratum in Colombia is a classification that the government give to the households. The taxes and the cost of services are priced depending on the features of the houses and their location. Stratum 6 is where the wealthiest people live and Stratum 1, or no Stratum, is where the people with less income live. With this classification the high-income households finance the services and taxes of the low income households.

Most people in the sample belong to the Stratum 1, 2 and 4. In Figure 14, we can see how these people opt to take virtual and blended education over physical. The reasons might be the financial cost of it. In addition, it is nice to realize how the technological change happening in the education sector is directly attacking the inequality by offering a chance to the ones that do not have the budget to assist a physical university.

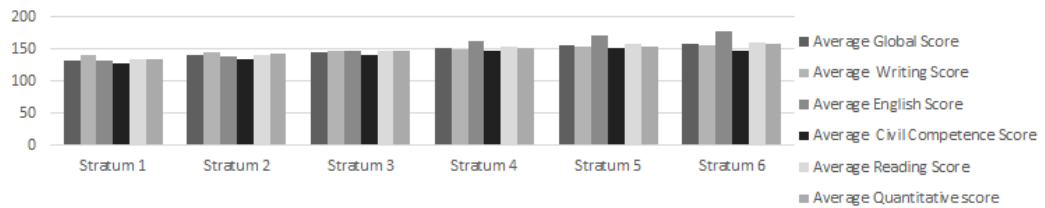


Figure 13. Average Score according to the Stratum of the student.

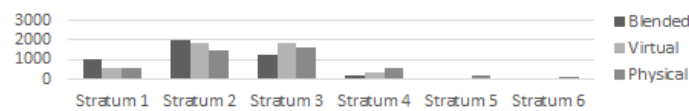


Figure 14. Type of education according to the Stratum of the student.

## Academic Background of the Parents

Furthermore, in the sample, when the parents together, or only the mother, or only the father, achieved a postgraduate education, the results of the Saber Pro are significantly higher compared with parents with a lower education level. In the Figure 15 below, we can see the case for the father.

According to Figure 16, it seems irrelevant for fathers with technical or high school education what type of education their sons and daughters receive. Parents with a more advanced level of education clearly opt to offer the same for their children.

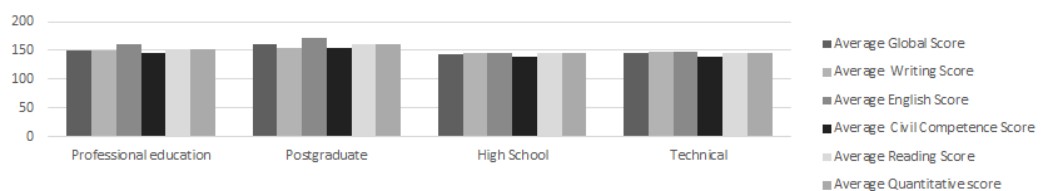


Figure 15. Average Score according to the father's academic background.

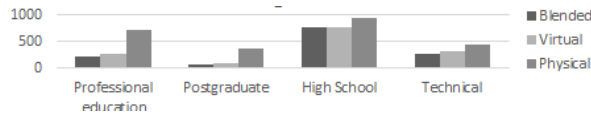


Figure 16. Type of education according to the father's academic background.

## Legal Registered Type of Institution

The higher education in Colombia differentiates the types of institutions according to their academic offer. Universities are the higher category because they do not only teach a specific matter, but also general knowledge about different topics that are not related to the career chosen. The lowest category, or the most specific one, is technical education. In this type of category people learn the necessary practical skills they need to perform jobs that are part of the basic economy, i.e. machinery, construction, cooking, etc.

The university keeps offering the best quality education. Students learning from various types of knowledge build the character of good professionals. In every category, it outperforms the other types of institutions. Also, according to Figure 18, they value physical education more than the two other categories. Also, smaller, and less known university and technical institutions are opting to use virtual and blended education.

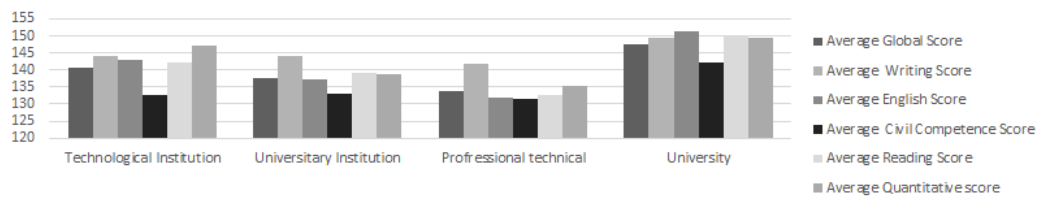


Figure 17. Average Score according to the legal registered type of Institution.



Figure 18. Type of Education according to the legal registered type of Institution.

## Number of Books Owned

Literacy never stops being a fundamental pillar of education. People that read more scored better at the Saber Pro than people that read less. Reading books, as traveling, opens the mind. Opening the mind feeds the curiosity for more knowledge, therefore, to pursue and to perform better at education. For that reason, according to Figure 19, people that read more obtain better scores in the Saber Pro. Also, the more books you read; the more likely students are to choose physical education (Figure 20).

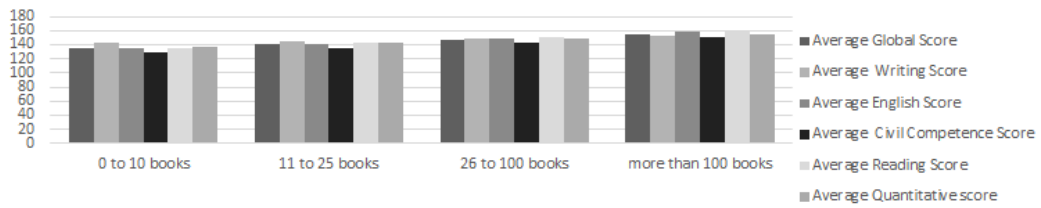


Figure 19. Average Score according to the number of books owned by the household of the student.



Figure 20. Type of education according to the number of books owned by the household of the student.

## Tuition Fee Method of Payment

Students that have their parents, a scholarship, or a credit to pay for the tuition fees perform better on average than students that must pay their education for themselves. The mechanism that explains this difference in the results is probably related to the availability of time to study. Working full-time and part-time jobs and having financial stress in life also reduces the energy to study.

According to Figure 22, people that are not paying their studies themselves, usually have the support from their parents, scholarships, and credits. It allows them to choose a physical education while students that must work for it, usually do not earn enough to attend it. As shown before, physical education still holds the best results in the Saber Pro, but it is also the most expensive way to get educated.

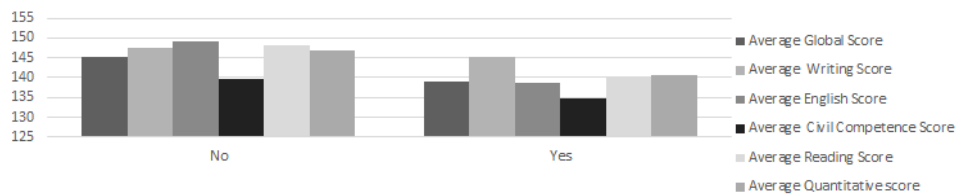


Figure 21. Average Score according to if the student paid the tuition fee by himself/herself.



Figure 22. Type of education according to if the student paid the tuition fee by himself/herself.



## 4.3 Empirical Strategy

To provide an answer to the proposed Research Question, we will consider the influence of socio-economic conditions of students for every type of education in three different models. Then, in a fourth model, we will use one single and merged sample of the data to analyze the influence of the type of education itself on the student performance.

The underlying questions related to the four models are:

1. To what extent the socio-economic conditions of the students enrolled in physical educational institutions affect the results of the Saber Pro Test?
2. To what extent the socio-economic conditions of the students enrolled in virtual educational institutions affect the results of the Saber Pro Test?
3. To what extent the socio-economic conditions of the students enrolled in blended educational institutions affect the results of the Saber Pro Test?
4. To what extent the type of education chosen by the students affect the results of the Saber Pro Test while controlling for their socio-economic conditions?

The methodology for quantitative analysis is divided in two steps. In the first step, the first three models use an OLS regression to relate the socio-economic characteristics of every type of education to the Global Score of the Saber Pro Test. Global Score is the dependent variable of the model and it is an average score of the different modules of the test: quantitative, reading, English, writing and civic competences. In the second step, Model 4 includes all the socio-economic variables and shows the influence of the type of education in the Global Score of the test.

All the socioeconomic variables are non-numeric variables and they were given numerical values. Then, we created dummy variables for each of the categories mentioned to make logical the interpretation of the results. We used the control variables because they hold a theoretical and empirical relevance for the learning outcomes of the students. Furthermore, they are itself variables of interest in the first three models. We want to know to what extent those socio-economic conditions are affecting the results. We can know what are the most relevant socio-economic factors that influence the learning outcome of the students for every type of education. Then, when controlling for those factors we can know if the type of education alone is a variable that affects the performance in the Saber Pro test.

The control variables related to the students are the sex, the ethnicity, if the person studied abroad or not and if the person is paying himself/herself for the education. Then, the stratum, the academic background of the father and if the person lives in a rural area or not control for the conditions in which these students usually spend their lives on. In addition, from the side of the institution, we control for the price of the tuition fee and the legal type of institution. We argue that the more regulated and certified an institution the better the learning outcomes of their students. It is inevitable that these variables are correlated themselves to some extent, however, each of them represents specific and independent characteristics for the students and their education.

The socioeconomic variables of the equations from step (1) and (2) are the ones mentioned in the section 4.2. The full dataset contained very specific information of the individuals, i.e. if

the household of the student owned a washing machine or no. We decided to not get too specific on the socioeconomic factors and make the model as simple and explanatory as possible. For instance, instead of considering the education of the mother, we only consider the education of the father as it works as a proxy for both parent's education. Instead of using the exact location of the university or of the household, we only consider the Stratum and if it is in a rural area or not. For the individual itself, instead of considering how much time was spent studying, playing videogames, or watching TV, we only consider how many books he/she owned. We expect that the variables with the highest impact will be the Ethnicity, the Sex and the Legal Registered Type of Institution in which the student is enrolled, as shown in the descriptive statistics of Section 4.2.

$$(1) \text{ GlobalScore}_i = \beta_0 + \beta_i (\text{SocioeconomicVariables})'_i + \varepsilon_i$$

$$(2) \text{ GlobalScore}_i = \beta_0 + \beta_1 \text{Type of Education} + \beta_{i+1} (\text{SocioeconomicVariables})'_i + \varepsilon_i$$

The decision to use an OLS regression is because of its usefulness to identify what factors are important or affect a certain variable. As mentioned before, we are fully aware that in the socioeconomic conditions variables there might be multicollinearity problems. A clear one, is that in Colombia people from minor ethnic groups tend to live in rural areas, live in lower Stratum or have parents with less education. Also, as in our case, the OLS regression is a method useful when having a random sample of observations. We consider this method to be the best to conduct our analysis because it is simple, practical, and all the variables hold a linear relationship with the learning outcome of the student, i.e. learning outcome changes according to the levels and/or categories of the variables.

Moreover, we also argue that qualitative variables like teaching methodologies, quality of professors, vision of the institutions and use of technologies are implicit on the type of education. In the literature review, we discussed the relevance of the virtual education but to understand it alone it was necessary to first control for the socio-economic conditions. By understanding the people behind the different types of education, we can discover where the opportunities for improvement may rely on. With this empirical strategy, we want to disclose those opportunities that need not only to be discovered, but considered, and taken by the education technologies.

## 5 Analysis and Discussion

In this section, we present the results of the models proposed. Also, we open the discussion for the role of the education technologies on transforming the education in Colombia.

### 5.1 Results

In this section, we present and analyze the results of the Models 1-4 in the Tables 1-4. Then, we present the summary of results in Table 5.

In the results below, we can see that students taking virtual education, in accordance with the critiques and previous studies of Section 2.2, are performing less good in the Saber Pro Test. The technologies related to this type of education have not found the way to make it better than the physical competitor. Surprisingly, blended education performs no better than virtual education. The difference is not big enough, but it shows that virtual education is not doing everything wrong either.

For physical education, the ethnicity and if the individual has no Stratum, or he/she is Stratum 1, hold the highest negative significant impact. On the other hand, the highest positive influence is given by the highest category of the Tuition Fee. However, free Tuition Fees are also impacting almost as much as the highest category. Public universities like Universidad Nacional de Colombia are highly competitive institutions with a strong student community. These universities usually do not charge Tuition Fee for the lowest Stratums, however, to get in, people need to have a required amount of knowledge that is costly to get which at the end pivots the entrance of only medium and medium to high Stratum students.

For virtual education, if the father has no education affects the most the results of the test for the students. This is not an atypical case in the country. Usually these people are from minor ethnic groups and have suffered the consequences of being excluded from the modern society. It is unknown what is the mechanism behind the connection between the father's education and the learning outcome. Yet, the values of the person and the growing mindset mentioned before in the Section 2.1 are as important as the economic background itself of the person. We argue that ambitious children have usually ambitious parents. If they did not achieve much in life, they will have nothing to tell their children to fight for. But, if they have achieved even a minimum level of education, they will know how important it is for the professional and educational future of the individual. Therefore, they will promote that the student achieves what his/her parents could not.

For blended education, the ethnicity has a larger negative effect than the virtual but smaller than the physical education. It seems quite certain that the cultural intrinsic aspect of the individual is affecting the way the live their student life. In addition, it means the efforts of the government are not reaching the most vulnerable population.

Variable	Coefficient	Std. error
Masculine	3,67***	0,59
Ethnicity_Yes	-8,13***	1,25
City_Yes	6,04***	0,96
TuitionFee_<500K COP	7,79***	1,02
TuitionFee_+7MM COP	12,64***	1,17
TuitionFee_1MM COP - 2,5MM COP	-0,59	0,90
TuitionFee_4 MM COP - 5,5 MM COP	1,97*	1,04
TuitionFee_500K COP - 1 MM COP	3,98	1,08
TuitionFee_5,5MM COP-7MM COP	3,23**	1,34
TuitionFee_0 COP	7,98**	3,08
SelfPaid_Tuition_Yes	-1,95***	0,63
FathersEducation_HighSchool_Completed	1,74	1,25
FathersEducation_ProfessionalEducation_Completed	3,18**	1,35
FathersEducation_PrimarySchool_Incomplete	-0,7	1,30
FathersEducation_ProfessionalEducation_Incomplete	7,31***	1,69
FathersEducation_HighSchool_Incomplete	2,54*	1,38
FathersEducation_Nothing	-3,71**	1,91
FathersEducation_Postgraduate	6,56***	1,59
FathersEducation_Technical_Completed	2,10	1,43
FathersEducation_technical_Incomplete	3,25*	1,83
FathersEducation_DoesnotApply	-0,44	2,82
FathersEducation_Doesnotknow	4,93**	2,35
Stratum_2	-3,03***	0,72
Stratum_4	2,22**	0,99
Stratum_5	4,82***	1,49
Stratum_1	-7,10***	1,00
Stratum_6	2,69	2,00
Stratum_None	-10,26***	3,75
NumberofBooks_11-25	-6,84***	0,76
NumberofBooks_+100	3,68***	0,98
NumberofBooks_0-10	-10,61***	0,78
LegalEducationType_University	4,28***	0,75
LegalEducationType_ProfessionalTechnical	-4,69**	2,08
LegalEducationType_TechnicalInstitution	2,36	2,35
const	144,31	1,66
Number of Observations	4445	
R-squared	0,27	
S,D, dependent var	22,36	
Mean dependent var	152,61	

Standard errors in parentheses

\*\*\* p<0,01, \*\* p<0,05, \* p<0,1

*Table 1. Model 1. Relationship between saber pro test results and socioeconomic background for physical education.*

Variable	Coefficient	Std, error
Masculine	4,50***	0,55
Ethnicity_Yes	-4,7***	1,08
City_Yes	2,75***	0,75
TuitionFee_500K COP - 1 MM COP	-2,6**	1,26
TuitionFee_<500K COP	-0,8	2,10
TuitionFee_2.5MM COP - 4MM COP	2,48*	1,25
TuitionFee_4 MM COP - 5.5 MM COP	7,49**	2,84
TuitionFee_5.5MM COP-7MM COP	8,45	5,50
TuitionFee_0 COP	-1,65	4,10
TuitionFee_+7MM COP	-25,41	17,34
SelfPaid_Tuition_No	-0,4	0,64
FathersEducation_Nothing	-8,2***	1,23
FathersEducation_HighSchool_Completed	0,15**	0,95
FathersEducation_PrimarySchool_Incomplete	-2,7***	0,86
FathersEducation_ProfessionalEducation_Completed	1,27	1,30
FathersEducation_Postgraduate	2,64	2,03
FathersEducation_ProfessionalEducation_Incomplete	-3,5**	1,53
FathersEducation_technical_Incomplete	-4,2***	1,54
FathersEducation_PrimarySchool_Completed	-1,6	1,03
FathersEducation_Technical_Completed	0,51	1,23
FathersEducation_Doesnotknow	3,75*	1,91
FathersEducation_DoesnotApply	-3,35	2,24
Stratum_1	-7,6***	0,88
Stratum_2	-2,3***	0,59
Stratum_4	2,20**	1,05
Stratum_None	-6,2*	3,73
Stratum_6	0,72	3,19
Stratum_5	3,51**	1,93
NumberofBooks_26-100	2,69***	0,69
NumberofBooks_0-10	-4,1***	0,63
NumberofBooks_+100	6,82***	1,11
LegalEducationType_University	4,56***	0,88
const	140,88	1,10
Number of Observations	4477	
R-squared	0,27	
S,D, dependent var	18,58	
Mean dependent var	141,57	

Standard errors in parentheses

\*\*\* p<0,01, \*\* p<0,05, \* p<0,1

*Table 2. Model 2. Relationship between saber pro test results and socioeconomic background for virtual education.*

Variable	Coefficient	Std, error
Masculine	4,033***	0,57
Ethnicity_Yes	-6,20***	0,92
TypeofResidence_Rural	-2,13**	0,74
TuitionFee_2.5MMCOP - 4MM COP	-0,64	1,60
TuitionFee_<500K COP	-2,12**	0,99
TuitionFee_500K COP - 1 MM COP	-3,33***	0,68
TuitionFee_0 COP	-6,69	4,33
TuitionFee_+7MMCOP	-14,8	16,68
TuitionFee_4 MM COP - 5.5 MM COP	-4,18	8,38
SelfPaid_Tuition_No	-0,88	0,56
FathersEducation_Nothing	-4,79***	1,35
FathersEducation_HighSchool_Incomplete	0,413	1,27
FathersEducation_Postgraduate	5,226**	2,28
FathersEducation_PrimarySchool_Completed	0,110	1,26
FathersEducation_HighSchool_Completed	1,921	1,22
FathersEducation_PrimarySchool_Incomplete	-0,74	1,15
FathersEducation_ProfessionalEducation_Completed	-0,97	1,57
FathersEducation_technical_Incomplete	-0,98	1,77
FathersEducation_ProfessionalEducation_Incomplete	-0,76	1,82
FathersEducation_DoesnotApply	0,173	2,32
FathersEducation_Doesnotknow	1,801	2,20
Stratum_3	5,664***	0,75
Stratum_2	3,885***	0,68
Stratum_6	-7,07*	4,09
Stratum_4	6,790***	1,38
Stratum_None	-6,55**	2,65
Stratum_5	-1,85	2,30
NumberofBooks_26-100	4,362***	0,68
NumberofBooks_0-10	-3,40***	0,61
NumberofBooks_+100	4,754***	1,16
LegalEducationType_University	3,222***	0,59
LegalEducationType_ProfessionalTechnical	1,031	1,16
LegalEducationType_TechnicalInsitution	18,68*	9,63
const	131,30	1,31
Number of Observations	4373,00	
R-squared	0,27	
S,D, dependent var	17,72	
Mean dependent var	134,79	

Standard errors in parentheses

\*\*\* p<0,01, \*\* p<0,05, \* p<0,1

*Table 3. Model 3. Relationship between saber pro test results and socioeconomic background for blended education.*

Variable	Coefficient	Std, error
Masculine	3,88***	0,34
Ethnicity_Yes	-7,72***	0,64
TypeofResidence_RuralArea	-3,63***	0,49
TuitionFee_2,5MM COP- 4MM COP	-1,70***	0,62
TuitionFee_<500K COP	2,68***	0,69
TuitionFee_500K COP - 1 MM COP	-1,33**	0,56
TuitionFee_0 COP	-1,20	2,14
TuitionFee_4 MM COP - 5,5 MM COP	0,72	0,91
TuitionFee_+7MMCOP	13,0***	1,06
TuitionFee_5,5MM COP-7MM COP	3,02**	1,23
SelfPaid_Tuition_No	0,47	0,37
FathersEducation_Nothing	-7,2***	0,89
FathersEducation_HighSchool_Incomplete	-0,1	0,76
FathersEducation_Postgraduate	4,63***	1,07
FathersEducation_PrimarySchool_Completed	-1,49*	0,79
FathersEducation_HighSchool_Completed	0,04	0,72
FathersEducation_PrimarySchool_Incomplete	-2,63***	0,70
FathersEducation_ProfessionalEducation_Completed	0,47	0,83
FathersEducation_technical_Incomplete	-1,55	1,06
FathersEducation_ProfessionalEducation_Incomplete	0,48	1,02
FathersEducation_DoesnotApply	-2,17	1,50
FathersEducation_Doesnotknow	3,41**	1,33
Stratum_3	7,08***	0,52
Stratum_2	4,58***	0,50
Stratum_6	8,03***	1,62
Stratum_4	8,87***	0,75
Stratum_None	-5,81***	1,94
Stratum_5	9,45***	1,14
NumberofBooks_26-100	4,66***	0,43
NumberofBooks_0-10	-4,14***	0,40
NumberofBooks_+100	8,12***	0,65
TypeofEducation_Blended	6,19***	0,42
TypeofEducation_Physical	9,91***	0,51
LegalEducationType_University	4,89***	0,42
LegalEducationType_ProfessionalTechnical	0,36	1,08
LegalEducationType_TechnicalInstitution	-0,23	2,18
const	128,94	0,85
Number of Observations	13725	
R-squared	0,26	

Standard errors in parentheses

\*\*\* p<0,01, \*\* p<0,05, \* p<0,1

*Table 4. Model 4. Relationship between saber pro test results and type of education controlling for the socioeconomic variables.*

In Table 5, we present the summary of the results which also answer the research questions. It shows the comparison between the different Types of Education according to the influence of each of the socio-economic variables chosen.

Variable	Research Question 1	Research Question 2	Research Question 3	Research Question 4
Type of Education	Physical.	Virtual.	Blended.	It influence the results of the students. Physical education keeps leading the way. Physical universities have the best students.
Masculine	Men tend to score better than women.	Men tend to score better than women. The influence is higher than in Physical Education.	Same as Physical education.	In general, being a man influences the results of the test.
Ethnicity	Being from a minor group is clearly a problem.	Being from a minor group is clearly a problem. However, it is half the problem than it is in Physical Education.	Slightly less than Physical education and way more than virtual education. Being from a minor group is clearly a problem.	In general, being from a minor ethnic group has a profound negative effect in the results of the test.
Type of Residence	Living in the city is significantly better than living in the rural areas.	Living in the city is better than living in the rural areas. However, only a third of the effect that it has for physical education.	Same as Virtual Education.	In general, being from a rural area has a negative effect in the results of the test.
Tuition Fee	Students that are paying low tuition fees are performing good. However, the highest payers hold the best the results.	There are not 99%+ significant tuition fees categories. It seems almost irrelevant to influence the Saber Pro scores. However, people that pay between 4MM COP and 5.5MM COP obtain a significantly higher score.	It seems also irrelevant to influence the scores of the test. Only paying tuition fees under 1MM COP affects negatively the results of the test.	In general, the highest tuition fees perform, by far, better than the low tuition fees. Tuition fees that are lower than 500K COP also influences the results positively.
Self-Paid Tuition	It is a problem. Students that pay their tuition by themselves are performing less good.	It is not relevant for the score of the test.	Same as Virtual Education.	In general, it does not have an effect on the results of the test.



Father's Education	There is a strong influence. Students with Professional Education Incomplete tend to have the best results followed by fathers with Postgraduate Education.	Professionals and Postgraduates father's education has no influence in the results. Father's education that is incomplete affects slightly negatively the results.	Only fathers with postgraduate education affects positively the results and only fathers with no education affects negatively the results. It does not have much influence.	In general, like in Blended education.
Stratum	Being from Stratum 1 and living in places where there are not even Stratum influences very negatively the results. Stratum 5, and not 6, is the one performing better.	Same as with Physical Education regarding Stratum 1 and 2. Being from higher stratum makes not much difference.	Being from Stratum 6 affects negatively. Stratum 2,3 and 4 are positively and proportionately related to the results.	The higher the stratum the better. To have an stratum it is already positive. To live in a place without one, it affects negatively the results of the test.
Number of Books	It will affect considerably and negatively if a student do not own more than 100 books	Having less than 10 books affects very negatively the results. It is clear that the more books the student have the better.	Same as with Virtual Education.	In General, students with more than 10 books at home will perform better. Having more than 100 books increase 2X the positive influence on the results.
Legal registered type of education	Universities are the best performers. The universal knowledge affects very positively the learning outcomes of the students.	Same as with Physical Education. Being registered as a University is a boost for the results.	If the institution is a Technical institution it will score significantly higher than if it is an university.	Being an University is in general the best way to assure a good performance for the students. The legal requirements that it takes are worth it.

Table 5. Answers to the Research Questions.

## 5.2 Validity and Reliability

The data is rich; however, it still has some reliability issues. Around 40% of the students that took the test were men. For that reason, trying different random numbers to pick a random sample always considered a higher number of women than men. Regarding the type of education, there is a clear selection bias because it is not completely random that people usually choose the different types of education. The socioeconomic conditions in which a young Colombian High School graduate strongly affects the career, the city, and the type of education he/she will pursue. It also creates multicollinearity problems in the model that made our estimates very sensitive. Yet, we consider to be moderate multicollinearity, and therefore, a minor problem as the results make sense with the previous literature review. In addition, the sample only consider educational institutions registered in Colombia. Students that are studying virtually from international platforms or in the distance at foreign universities are not forced to take the Saber Pro test.

About the models, we conducted test for Normality of the residuals and for heteroskedasticity. Both formal tests rejected the respectively null hypothesis, therefore, they reduce the credibility

on the results. However, when displaying the QQ plots and the normality of the residuals they look trustable enough. Therefore, we consider that the results we obtained can be used to draw conclusions. The tests are presented below:

### Model 1. Physical Education

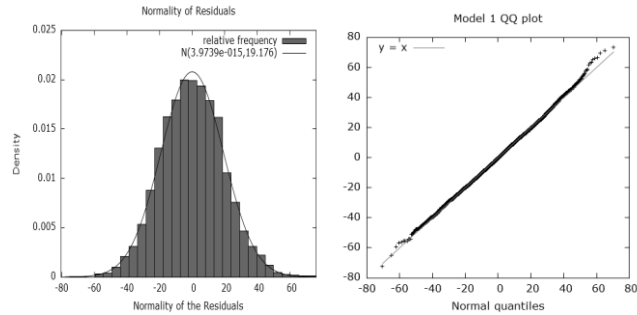


Figure 23. Normality of residuals and QQ-Plot for model 1.

### Model 2. Virtual Education

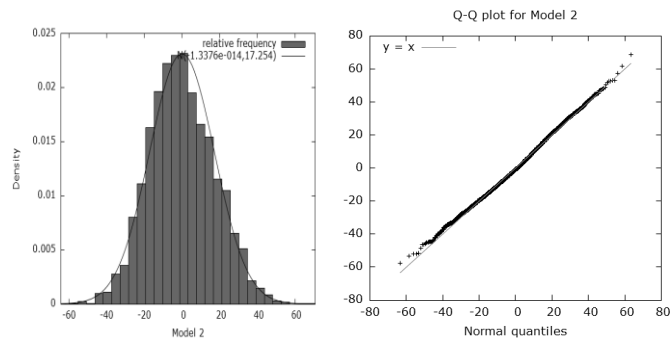


Figure 24. Normality of residuals and QQ-Plot for model 2.

### Model 3. Blended Education

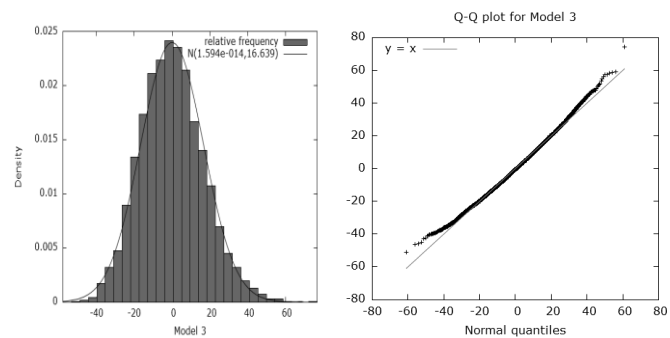
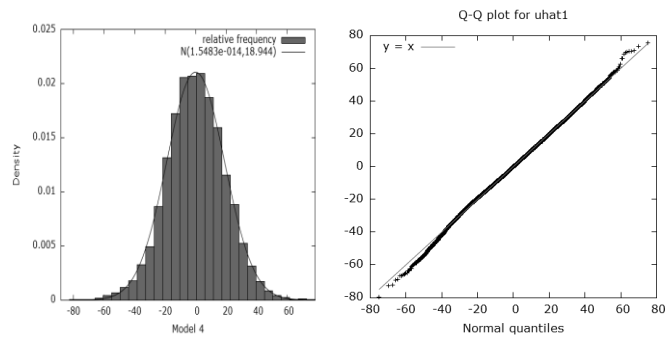


Figure 25. Normality of residuals and QQ-Plot for model 3.

### Model 4. Types of Education.



*Figure 26. Normality of residuals and QQ-Plot for model 4.*

## 6 Discussion

In this section, we discuss the results. We present the transition framework applied to education technologies and policy recommendations for improving the quality and accessibility to education in Colombia regardless of the socio-economic conditions of the individuals.

### 6.1 Discussion

The more socio-economic developed countries are the more they will benefit from virtual education. Colombia is on its way to provide better life conditions for its citizens. Yet, in the rapid changing times we live in, it is necessary to stress the importance that virtual education have on coping with the population differences and speed up the economic development of the country. Students that decide to take Virtual education do not need to worry if they are from a minor social ethnicity group, if they are working to pay their own tuition fees, if they are paying an expensive or not tuition fee, if the father has not achieved a high education level and if they do not belong to a medium to high social stratum. What really matter is how many books they own which can be understood as a proxy of how open minded they are. What matter for virtual education is the student itself, it is what every person has inside that they can exploit. Still there will be other factors affecting the learning outcomes, but at least, we are not in a point in which a student socio-economic condition puts him straight into a lower performance. For that reason, it is worth understanding how this transition, towards an education landscape in which socio-economic conditions do not matter as much, could take place in the country.

The role of education technologies is to support a cultural transformation that can decrease the negative effects of the significant variables of the socioeconomic background of the students. Technologies in education are less costly and faster to implement than physical schools. There are multiple solutions available. For instance, instead of building new infrastructure in a community located high up in the mountains and paying five teachers full time to go to schools, local governments can boost the use of laptops and internet. They can connect those students with the best qualified teachers and promote that parents can make the role of their education partners. Parents can learn how to do this too. In Sweden, parents go to school and organize activities, it is not impossible for local communities to rotate parents to take care of the children while they learn on their laptops. Education technology suggest a change in the mindset of what schools should be like since the individuals are children. The lifelong learning experience starts as soon as the kid is born. One more benefit to think about the role of technologies is that these devices are going to allow the education throughout the all life not only during school days. The more connected these people are to the mainstream knowledge the better for the Colombian society. Low income people do not know that they do not know. Technology might be the way in which they not only have access to social media, but also to quality unbiased education that awakes their curiosity and exploits their potential.

## 6.2 Transition framework

As discussed previously, virtual education in Colombia represents an opportunity to accelerate economic growth and slow down inequality increase. Higher Education goes from a traditional methodology of educating (in which there is a classroom, with students and a teacher) to a virtual and online experience. The Multi-Level Perspective framework understands this transition as outcomes of alignments between developments of multiple levels (Geels & Schot, 2007). The results obtained in the empirical analysis showed the learning outcomes of students regarding the type of education and the socio-economic conditions. The goal of this section is to use the transition framework to show the path in which education technologies can transform the education socio-technical system. The actors and creators in the transformation need to consider the variables that were significant and influential for the learning outcomes. Also, using the transition framework allows us to complement the results and open the discussion for the starring role of education technologies.

The multiple levels are the socio technical regime, the niche innovations, and the landscape pressure. The socio technical regime stabilizes the trajectories of the transitions and is composed of social groups and their alignment of activities. Scientists, policy makers, engineers, users, and special-interest groups related to virtual education. In this research the current socio technical regime is described as the normal way of teaching. It can consist of physical universities, teachers, students, and companies profiting from the current education system. These companies are the ones that create the most friction to change as they are going to lose market and become not innovative.

Virtual Education is just one of the technologies that will impact the all education system. It is composed of multiple technologies: video calls, webinars, e-learning platforms, automatic grading and testing, online payments, digital certificates, digital badges, video makers and content creators. Private new companies are leading the way because it is much easier to have started virtually than to move from a traditional and physical complex structure towards digital education.

To apply the methodology (MLP), we must select the empirical level of analysis of the object. For virtual education we will use the variable and object virtual classroom software. Then, we analyze the massive adoption of virtual classroom software in higher education in Colombia. Herein we are assuming that virtual classroom software massification is the direction in which most universities and technical higher education institutions will take. However, by no means this level selection is reducing the understanding of the system. We must consider the policies, the cultural evolution and reaction and the beliefs of the actors involved. The key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products are to be considered part of the socio technical regime.

We must also understand the short history of the virtual online education situation in the world. Virtual education in practical terms started with Youtube videos, around 2005, posted by teachers explaining math to frustrated students. It opened the business opportunity for Udemy which in 2009 started posting the same content on its platform, with best quality, and charging a fee for it. Afterwards, videos turned into live classes with Coursera forcing gathering an online community together to assist a live class instead of a pre-recorded video. Different companies started creating full programs which cost more than 800 USD and other companies focused on

small skills charging less than 50 USD. The most recent situation is Lambda school which charges students only after they have found a job.

History tells us that even though the scope of this thesis deals with Higher Education in Colombia, because we live in 2020, the world is fully connected, and the Colombian virtual education institutions are competing with the leading global education firms. Also, history and global context has taught us that student engagement and the cost of education are key variables. In e-learning, less students finish their programs compared to face to face education. Even though the goal for a successful virtual education is not entirely objective, we assume that it is to evolve into a stable innovative system that can provide value to the students, i.e. reasonable cost, good experience and job opportunities.

The relevant actors of the transition are the students, the decision makers in higher education institutions, the ministry of education and the companies, public or private, that will employ the graduates. In addition, one needs to consider the current providers of services and goods to the current system as they have a clear economic interest against the change of the state of the regime.

About the universities, in Colombia and in the world, they have failed to keep up with the changes in the labor market. Virtual schools can fill the gap for the lack of training in necessary skills that prepare the leaders to work in technology. Universities and institutes can launch a course, or a group of them, that is shorter, cheaper, and faster to produce than what the creation of a new career at one university could take. Universities are taking a passive action strategy against technology. The old traditional universities in Colombia are taking small and slow steps to incorporate the technologies. The speed on the transition depends mostly on the directors of the IT departments at universities, but still is the responsibility of teachers, students, and every implicated actor to demand more virtual education.

Companies are also benefiting from the current teaching methods. Just to mention a few: there are companies that secure physical documents, photocopy stores, notebooks producers, markers producers, architectures, construction business, academic editorials, teachers themselves, restaurants, bars, shopping malls, transport and the list goes on and on. Physical education has not changed for the last 100 years, as Robert Hawkins expressed. The same market conditions, the same teaching methodologies and evaluations have sustained a strong conservatism that made possible the internet, high speed railways and airplanes. It has proven to be effective to develop other industries, but it is not evolving itself.

Furthermore, the agency of the transition comes from the current education regime but also from the niche innovations. Both levels have regulative, normative, and cognitive rules. When the two levels start sharing these rules the action becomes coordinates and speeds up the transition. As Geels & Schot (2007) mention, technological niches and socio technical regimes are similar kinds of structures that only differ in size and stability.

In the case of virtual classrooms, they have no direct regulation from the government or entities besides the guidelines mentioned before. Different companies related to the ed tech sector come together to develop their own standards and laws, i.e. Open Badges as an international skill standard that involves technological and methodological requirements. In Colombia virtual education is forced to adapt to presential standards and not to create their own regulation. When courses go from presential to virtual, they tend to also copy the regulations that affect them. Nossa (2005) analyzed the minimum quality conditions, regulated by Decree 2566 of 10 of September of 2003, for providing academic programs which are based on:

1. Denomination: it must include program type, modality and level of formation provided.
2. Justification: the global relevance of the program, the professional opportunities, the current state of that area of knowledge and the characteristics that identify it.
3. Curriculum aspects: the program must include the theoretical, practical and methodological rationale, the principles and goals that guide the formation, the structure and content of the courses and the model and pedagogics strategies. This regulatory aspect is defined by a team conformed by the Ministry of Education, higher education institutions and faculty associations.
4. Organization of the program using academic credits.
5. Research component: the program must include the means to develop research and to have access to the progress of the specific body of knowledge.
6. Selection and evaluation of students: the program must include clarity about the requirements for admission of students and define the academic achievements that sustain the progress of the student until graduation.
7. Academic personnel: there must be a guideline to promote the quality of the people that will oversee the administrative, teaching and any other nature of supporting role for the student.
8. Educative means: the program must provide a library, information technology solutions for the users and onboarding processes to learn how to use those resources.
9. Infrastructure: Presential education must include a physical location. In this aspect, there is not guidelines for the infrastructure of the virtual education classrooms.
10. Academic and administrative structure: the program must be connected to a faculty, school, department or similar. Those must fulfill minimum requirements of quality regarding organizational structures and connection with other academic units.
11. Self-assessment: the program must periodically carry a self-assessment to look for improvement opportunities.
12. Policies and strategies to follow the graduates: the program must measure the social impact and the professional performance of the graduates whenever is necessary. It also must provide useful content for students after they graduate and encourage the exchange of professional and academic experiences.
13. Wellbeing: the institution behind the program must include an internal regulation and a general plan to promote and execute the actions that produce a good wellbeing of the students.
14. Financial resources: the program must demonstrate that it has the financial resources to guarantee the smooth functioning of the program during the period of the qualified register obtained by the government.

Furthermore, the Decree 1295 of 2010, forces presential higher education institutions to register as virtual education providers if they start using virtual education as a methodology for teaching. Therefore, even though the government sets a clear differentiation ICT for ed tech can come to support the current state of the schools without transforming them fully digital. The good side of the regulation is that a fully virtual institution that follows the regulation will achieve an extraordinary level of formality. They are not forced to, but they can do it.

In the normative rules are the role relationships, values, and behavioral norms. Gomez & Perez (2015) exposed that the actors in Colombia involved in the current education socio technical regime are focused more on adapting to the current social demand for education than to facilitate the adoption of new education technologies. Therefore, niche technologies are not in the first line of action of universities. The postponement of action will produce heavy consequences on the quality and competitiveness of education in relation with global standards.

The decree 1295 of 2010 also leads the action regarding IT investments in Education. Universities are forbidden to use virtual classroom education technologies unless they register as a virtual education institution. The consequence is that the top universities are not likely to get involved in education technologies which causes that perception that methodologies and the quality of the graduates is lower than presential education (Gomez & Perez ,2015). If the good quality universities, measured as positions in the QS ranking, get involved in the technology the perception will not improve. In this respect, in the year 2020, Universidad de los Andes, the best university in Colombia by the QS ranking, has uploaded its first master's degree in Coursera platform. It marks an important milestone for virtual education and knowledge accessibility, and it shows the will from the leading educational institutions to start the modernization.

Moreover, niche technologies must work double to convince IT departments at universities that what they offer is going to help universities. Also, they decrease profit margins to close deals with universities and educational institutions because budget is always a restriction. The less money the niche technologies can make, the less they will continue to innovate and the less the current regime will adopt new technologies.

The cognitive rules are the beliefs that are behind the actions of niche technologies and the regime actors. They are *social constructs that convey information which distills and summarizes society's beliefs and experience* (Greif & Moky, 2017). People believe that certain actions will lead to certain outcomes. Disruptive ideas can lead to Universidad de los Andes uploading a master's degree course in Coursera, Pontificia Universidad Javeriana in Bogotá starts issuing digital certificates with Blockchain and that Q10 an international Learning Management System was born in Colombia. The market of ideas in education is highly conservative and difficult to change. The people financially behind the higher education institutions are actors with short term economic interest and a lack of access to technological knowledge. The people behind the niche technologies are entrepreneurs that look for an economic retribution above the social impact of the technology. Education has the normative and regulative rules in the background, but the cognitive rules are the one leading the action.

Cognitive rules are that going to university and studying for five years is better than to take a virtual course in Coursera which lasts for one month. For teachers, talking for an hour nonstop, while being aware that most students in the classroom are paying attention, and repeating the process until delivering an exam that forces the student to take active participation in the class is the right way of teaching. IT departments in universities leading the technological development decisions of universities, when an integrated group composed of students, teachers, administrators, academics, and any other actor linked to the university must be responsible for the improvement of their own experience. The lack of acting, of waiting that the government will force the change, have made the transition slower.

On the other hand, the unexpected circumstances that the COVID-19 has put on the education system has modified the way in which the actors perceive and care about virtual education, i.e. cognitive rules. When students could not go to presential classes and started taking virtual classes on Zoom, they questioned once more, if everyone should learn at the same speed. Virtual education provides learning at different speeds and in contradiction with the common belief, it can be more time demanding and people can learn more than in presential classrooms. The COVID-19 has put teachers questioning the way they evaluate students, at Universidad de los Andes, they are going from a standard evaluation test for everyone, to a more qualitative and personal form of evaluation of knowledge. The administrators and owners of physical



universities realized how old fashioned their education system has been and how technology is the path towards sustainable growth thanks to the pandemic.

The landscape of the socio technical regime can be understood as the technical, social, physical, and material environment that sustains society. Landscape cannot be modified by the actors of the regime or the niche, but it does influence the actions of them. The COVID-19 has produced a major economic crisis globally and has forced educational institutions to close their locations and go virtual. In addition, there is a global increase in the demand for professionals with technical and qualitative skills. The massive production of technologies in other industries has seen a massive demand for people qualified to develop those technologies. Traditional education has been unable to cope with the rapid need for those skills, giving opportunity for niche technologies to emerge and fulfill the gap. Also, traditional private education has been increasing prices for their tuition's fees to maximum levels. They grow higher than the inflation which causes less people to have a comfortable university life. The economic inequality and the constant worry with financial duties has made students choose to work full time and study virtual, or to study full time but get a credit they must pay after they graduate.

Besides, one can mention that the internet in general, the rise of Asia as the factory of the world, the political decisions of United States regarding the environment and migration, the presidential elections in Colombia which favored a candidate with a clear like for technologies, the access to internet from any region in Colombia, the inequality of the country, the favoritism for urban and central areas in the country over rural areas, the nutrition of people, the peace agreement of 2016 with the FARC, the cost of life of cities and of course Youtube, Instagram, Facebook and LinkedIn, are among the infinite landscape pressures that influence the normative, regulative and cognitive rules of the regime and the niche technologies of the education system.

The landscape typology used in Geels & Schot (2007) to illustrate the way it affects the regime and the niche innovations categorizes it in regular, hyper turbulence, specific shock, disruptive and avalanche. None of them are exclusive of a transition, nor all of them are happening at the same time. Depending on the timing on the transition a landscape pressure can affect the impact on the regime and niche technologies. They describe the way in which regime and niche reacts to change.

Regular change in the education sector has been the slow adoption of technologies by universities. They have included IT for security of information, learning management systems and custom management relationship software for accessibility of courses over the last ten years. However, the reaction towards developments in virtual classroom technology have been less advanced and has been stuck in PowerPoint presentations for the past years.

COVID-19 has made a Disruptive change that has transformed into a Hyperturbulence change. The Disruptive describes the extra low frequency of pandemics and their high intensity which has created a turbulent environment in the educational sector. The latter, the reaction of the regime to adopt, design and create fast new content, the ability to match better the demand for jobs. During the COVID-19, educational institutions have been graduating doctors and preparing them for the intensive care units in a matter of weeks. The niche technologies have more capacity of maneuver in their aims. If virtual classrooms are demanding a rapid certification, e learning platforms will start issuing digital certificates, automatically, when the courses are over. It describes the constant struggle of universities to keep producing research, to keep evolving their physical and digital infrastructures because of the high competition of the market. The education sector is highly competitive due to the high number of actors offering

the service. All of them want to have the best students and the best graduates so then they can keep growing economically.

Beyond Geels and Schoot (2007), the actions that the education sector can take are not limited to material exchanges, R&D investments, strategic coalitions, power struggles and competition. Lately, they have reacted by offering free open online courses and gathering and asking the government for support to deal with the economic crisis. Niche innovations, like Zoom in the educational sector, are having a massive surge in the number of users and changes in the purpose of their technologies. Zoom is being used as a virtual classroom, virtual evaluator and in general, as the online school academy. It is too early to say that the COVID-19 seems to be the unprecedented trigger for digital transformation.

The virus could be either a Disrupte-Hyperturbulence change or either just a Specific change. If it is the latter, things will go business as usual after the lockdowns. Educational institutions will keep believing that they must keep postponing innovations in the educational sector, until the time is right. The government will keep postponing the agenda to regulate virtual education. Students will keep having the perception that virtual education is less appropriate than physical education and companies will keep thinking that they rather employ an individual that went to a physically recognized university than an individual from a digital all new educational institution. The crisis is happening but as mentioned before, only the actions taken by the actors from the education regime and the niche innovations, are the ones that can speed up the transition.

The actions the actors can take have an evolutionary- economic perspective or a social-institutional one. These actions are endogenous of the system but influenced by the landscape environment. In the evolutionary perspective, the higher education socio technical system of Colombia is composed by physical universities with different knowledge bodies specialties. Just to mention an example, one university like the Fundación Universitaria de Ciencias de la Salud is focused on preparing doctors, Universidad Externado de Colombia is focused on preparing lawyers, and so on and so forth with the rest of institutions. All of them are the same and different in their strategic choices, investment partners and core competencies. All of them compete in a selection environment, in which only the one who adapts better to the circumstances and do so in the long term will gain the reputation and the credibility to prepare good students. The same happens with the niche socio technical systems at a lower level. The niche technologies compete between them to see who can get the biggest share of the market. They gather in groups to try to create the new standard for virtual education but until a fair share of the market uses their standard, they do not become the standards.

The role of evolutionary economics in these both socio technical systems lies down that any actor can develop a mutation at any time. This mutation can affect positively or negatively the company/institution. If the mutation, using the case of Universidad de los Andes adding one of its masters to Coursera, affects positively the engagement of its students, a selective natural process will provide the university with more resources to expand its mutation and make it the standard. Other institutions may want to copy the same process. Because Coursera only accepts higher educational institutions that are ranked high inequality, many universities and institutions will not have the chance to copy exactly what they are doing. The “other institutions” will tend to upload their content online through a virtual classroom experience. An opportunity for other niche technologies to copy what Coursera is doing but with a lower level of quality of institutions will appear. And because it is evolutionary economics the company that does it right and at the right moment will become the standard education technology. The

accumulation of these mutations can turn into stable regime structures with a predictable behavior.

In the social-institutional dynamic the actors of the regime, and the niche, acts upon the rules. An opportunity to upload a degree to an e learning platform is interpreted differently depending on the circumstances and the historical development of the institution. The concept of interpretative flexibility mentioned by Geels & Schoot (2007) and developed by Bijker (1995) explains the endogenous process in which education players explore different solutions to similar problems. When one of the players, who is already dominant, leading the way and the timing for digital transformation, for instance the decision of Universidad de los Andes of uploading a masters to Coursera, if it works, it will be sending signals to other educational institutions to solve the problems by uploading content online. For niche innovations, when a virtual classroom develops a feature, for instance, issuing digital badges to certify skills in the students. If it reaches masses and creates value, other niche players will notice it and implement it. The dynamic of these beliefs is discussed during conferences, research groups and professional organizations that are usually sponsored by actors that are looking to change the socio-cognitive institutionalization process of the niche and the regime in education.

Therefore, the endogenous change must be led by an actor, it must have an economic interest and it can be explained from a mix of evolutionary economics, and sociology of technology. It can happen at the level of the niche or the regime. No luck seems to play a major role in the process and little uncertainty is assumed when powerful technological and educational actors decide to try something new. The virtual classrooms companies are putting effort in forcing that virtual education is the better option and the traditional universities will keep forcing that physical education is the better. Both are in a creative process to mix each other, both are entering in a negotiation on how much the traditional education, that apparently has the larger market, is willing to lose to accept the transition. Coursera has more than 40MM students worldwide and its profits are higher than normal educational institutions compared to the 15k students in average of a higher educational institution in Colombia. The path seems obvious from an economic perspective, but it will depend on the interpretation of the players and how the landscape keeps intense pressure on the educational system.

After analyzing the structure in which the transition will take place, the education socio-technical regime is likely to follow a sequence of transition pathways. The COVID-19 is a landscape pressure that takes the form of 'disruptive change', beginning with (1) transformation, then followed by (2) de-alignment and (3) re-alignment (Geels & Schoot, 2007).

(1) In Colombia, the education has seen a change in the perceptions, belief systems, values, norms, and goals. During lockdown, qualitative evaluation has been taking place at universities using Zoom calls for teaching. Teachers have been forced to learn digital tools of teaching and students have realized how much they miss the physical act of going to school. The technology seems will never surpass the quality of human teachers, however if at certain point a machine that is 90% as effective as a teacher but costs 90% less, then it is likely to be considered by the administrative body of institutions. They are more open than ever to try new technologies. Nonetheless taking the first step towards a new technology venture is risky and it involves the coordination of multiple actors inside the institution and outside of it. We are talking about transformation because the basics of what an educational institution should be remains. The same educational institutions that have been in the market for more than 20 years, before the rise of modern virtual education, are transforming themselves to exploit digital technologies and supply the demand by the companies for useful 2020 knowledge, i.e. digital marketing,

climate change, practical coding, websites creation, sales strategies, blogging, e-commerce, world supply chains, etc.

(2) We are seeing how uncertainty has come to the educational sector in Colombia. The competition to provide it is between private and public universities, technical institutions, e-learning platforms, and MOOCs. The fully digital institutions lack the advantages of physical classrooms and common spaces for students. The fully physical institutions lack the usefulness and speed of knowledge creation, answering to doubts of students, managing physical documentation, costly payroll, etc. The COVID-19 has not only shown the advantages of digital education but also its negative aspects. The sudden need to go fully virtual, after the mandatory lockdown, made students to be forced to study virtually. The imposition of such a measure has not been well received by any of them. The perception of lack of empathy towards the physical and mentally situation of every one of the students has frustrated many of them. At home, not everyone has the same quality environment for learning. Differences in the desk, the chair, the type of laptop, the people you live with, the food you have access to, the Wi-Fi speed, in general, socio-economic differences cause more impact in the learning outcomes.

Currently, there is a phase of dealignment in which multiple niche technological solutions are shaking the education market. The framework would suggest that one innovation will become dominant and will become the core of the new realignment of the education socio technical system. Until the present moment, that innovation is the partnership of traditional education with platforms like Coursera who have the expertise of virtual classrooms and can upload content rapidly with great flexibility. Coursera has the trust of millions of people already internationally. Partnerships will also be developed with other builders of e-learning customized solutions. New payment methods for education, like the ones used by Lambda School, are to be incorporated and likely to become the rule. The competition for taking the lead is at its peak after the COVID-19 outbreak.

(3) The realignment may cause a technological substitution. Universities should not take for granted their historical dominance in the higher education market. They are already suffering and if measures are not taken, they will go bankrupt because the cost of a physical, digital, and teaching infrastructure will overcome the number of students taken. While Coursera can have more than 40 million students at its platform, Universidad de los Andes is overcrowded with tight schedule measures to maximize the space usage and the number of students admitted. Therefore, the actors that can be financially stable and the niche technology that receives a capital boost from investors are the socio technical actors that will end leading the way. Yet, no single actor can survive without cooperation. “2020 technological partnerships” by now is the leader of the transition.

### 6.3 Policy recommendations

Regarding the transition towards virtual education, supporting entrepreneurs and education technology companies with resources is a must. Designing mentorships, and accelerators program that can help the innovators to increase their market share will be useful for expanding the share of the use but also to improve its quality. These types of programs already exist like the one called “Aldea” designed by the government to promote all types of entrepreneurs and business has already boosted sales of the companies participating. However, there is a clear need to support entrepreneurs that can make the higher education more affordable and with

better quality. On the other hand, they should also incentivize through legislation, and not the opposite like the Decree 1295 of 2010, the use of new technologies. Public policy must regulate but also be flexible for providers of education.

Virtual education is the less dependent type of education with regard of the socio-economic conditions of students. Also, more than 60% of the students belong to the strata 1 and 2. Therefore, the public sector should review and invest resources in education policy that boost the use of education technologies. Special attention should be paid to promoting household reading and creating an inclusive culture with ethnicity minor groups. Not less important, it is necessary to keep empowering and to provide more support for women to study traditionally demanding careers like physics, mathematics, or engineering.

We specially recommend the government to be aware of what the leading countries regarding education success are doing. This can be done by promoting the cooperation between public and private higher education institutions from all around the world with Colombia. Events and fairs that gather the community together with due recurrence increase the chance of knowledge spillovers. The government should act at the best interest of the students and not the best interest of the old-fashioned educational institutions.

Regarding physical education, the institutions that are already having better learning outcomes but that are still not reachable to most students, must be open to introduce technologies that can spread their education. They should also act in the best interest of the students of Colombia and not to maintain their privileges of being the top educators. If they fail to do it, the market itself will decide for them.

Lastly, based on Mowat (2018), to improve the higher education ecosystem the government must consider a holistic view. Including all the actors in the developing of new policies may leverage the effect of those policies. Single actor directed strategies will have a narrow effect and will not deal with the cultural and socio-economic challenge of the country. Decision makers must understand that changing the education quality is also about changing the culture. We recommend getting people with experience and a more developed culture together with people with less of those two, to design and implement policies that have a technology component.

## 7 Conclusion

The COVID-19 has opened the mind of students, teachers, school directors, entrepreneurs, companies, and education policy makers. Globalization allows working and studying remotely from anywhere in the world, with any language and at low costs. There is a need to take action to embrace change and innovation in the education sector. Therefore, this research has mixed economic history, education technology, transition theory, and econometrics to support the movement of Colombia towards a more sustainable and digital education system. We document for the first time, to our knowledge, on a national scale the role and opportunities of education technologies to cope with the increasing population, the skills gap, the high number of higher education dropouts and the socioeconomic inequality.

In this study, we present a contextualization of the socio-economic factors that are affecting the learning outcomes of the students worldwide and we modeled them for Colombia. Then, we analyzed those factors according to the type of education taken by the students. We found out that socioeconomic factors have the less negative influence on students taking virtual education. For that reason, we opened the discussion for the transition framework. The implication of our work is to show the starring role of education technologies as the mechanism of a better and more accessible education in Colombia.

Besides presenting the socioeconomic factors that are affecting the learning outcomes by type of education in Colombia, our contribution is to provide useful knowledge to speed up the transition. This research sets the direction in which education technologies must be used. In Colombia, socio-economic conditions matter at different levels regarding the different types of education. The education technologies are already out there. For educational institutions performing good on the Saber Pro Test, they need the technology to attend a larger mass of students. For educational institutions performing less good on the Saber Pro Test, they need the technology to both improve the quality of the content, teaching and methodologies but also to expand their student's numbers.

Furthermore, it is the first time that transition theory is applied to the education socio technical system in Colombia, and anywhere, as far as we are concerned. It gives a picture of how and what is the role of every actor in the socio-technical education regime and in the niches. It also offers an understanding on how they interplay, what are the rules of the game and what are the motivation behind their behaviors.

The transition framework says that regarding the market share the transition has already taken place but regarding the performance until the results in the Saber Pro Test are at least equal, the transition needs work to be done. For that reason, carrying the similar model in a period of 24 months to check if the performance of virtual education has improved is necessary to check the development of the transition. Also, research is necessary to understand to what extent the students in Colombia are opting for the international virtual education market and the reasons behind it.

Our research has limitations because we did not consider the other psychological factors of the individuals, i.e. the growth mindset for example nor the operational mechanism in which technologies work. It is necessary to understand how the virtual education is operating in Colombia. With these we mean: what technologies they are using and how are their teaching methodologies, what is and what is not working. For all the types of education, if data regarding employability is available, or if surveys can be designed and conducted, researchers could know what type of education is more successful in the job market and what are the clear links between the different careers and skills taught by the educational institutions and their success in the job market.

Lastly, the study aims to reach the decision makers in education but also the students. The people between 17 years old and 25 years old are scared not to follow the traditional learning experience. This study wants to encourage them to pursue virtual education because it is cheaper, reliable, and fast compared with traditional education. At the same time, we urge them to call for the use of more education technologies. We want to let them know that regardless of the socioeconomic background they can still make a huge positive impact in the world by educating themselves.

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